ISOMETRIC DRAWING

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ISOMETRIC DRAWING

A TREATISE ON MECHANICAL ILLUSTRATING DEALING WITH TYPICAL CONSTRUCTIONS AND OUTLINING

A COURSE IN THE ART

BY

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PREFACE

The writer has been a teacher of mechanical drawing since the year 1895; during this time it has been his privilege and pleasure to instruct many students.

As a part of the course administered, each student has been given some instruction and practice in Isometric Drawing; this practice has been limited, because of lack of time to devote to it (most of the time assigned being given to straight mechanical drawing), but has always been of interest to, and appreciated by, the student.

Isometric Drawing is growing in popular usefulness, and one can hardly pick up a technical paper or magazine without finding one or more examples; its convenience and its adaptability are being recognized, and a knowledge of its execution is desirable and necessary for all draughtsmen.

All treatments of the subject known to the writer accompany a treatise on Descriptive Geometry, or are too short; in every case the subject is treated with more attention to theory than to its practicability.

The broad field for its use, its growing popularity, the enthusiasm with which a student " takes hold," and the nature of the present (known to the writer) texts on the subject have led the writer to believe that a plain exposition of the " How " of the art, with no reference to the " Why," may be of some service to teachers, students, and draughtsmen.

It is, therefore, with the object of presenting the subject in a new light or way, in the hope that others may find the art as useful as the writer has found it, in the hope of service, and not in the nature of a " This is better than thine " spirit, or in criticism of what has been written, that this work is offered.

A. P. Jamison.

Purdue University, West LaFayette, Ind.,
June 13, 1911.

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ISOMETRIC DRAWING

CHAPTER I

PRELIMINARY DISCUSSION AND EXPLANATIONS

1. Introductory.

To understand what is to follow, the reader must possess a working knowledge of mechanical drawing; assuming this much, then, it is proposed to present the Art of Isometric Drawing with but very little preliminary or preparatory explanation. Attention is to be given to the way in which a drawing can be made, rather than to the reasons for doing " thus and so."

Plain and common terms will be used in so far as they can be found to fit, and in the event a few unfamiliar words are used they must not be allowed to affect the reader's interest; as a matter of fact, the art is so simple, having but two principles or characteristics, that any draughtsman should have little, if any, difficulty in acquiring it.

Students are urged, therefore, to read this work through carefully, to study each successive step, as the subject is developed, to draw for themselves the several explanatory figures given in the text, and to further their working knowledge by the execution of the few plates given for this purpose in Chapter IV. Such attention will cover all of the essentials, and should furnish a knowledge of the art sufficient for practical use.

2. Definitions.

From an engineer's standpoint (so designated to distinguish it from the artist's standpoint), Drawing is divided into four main divisions, namely: Mechanical Drawing, Perspective Draw-

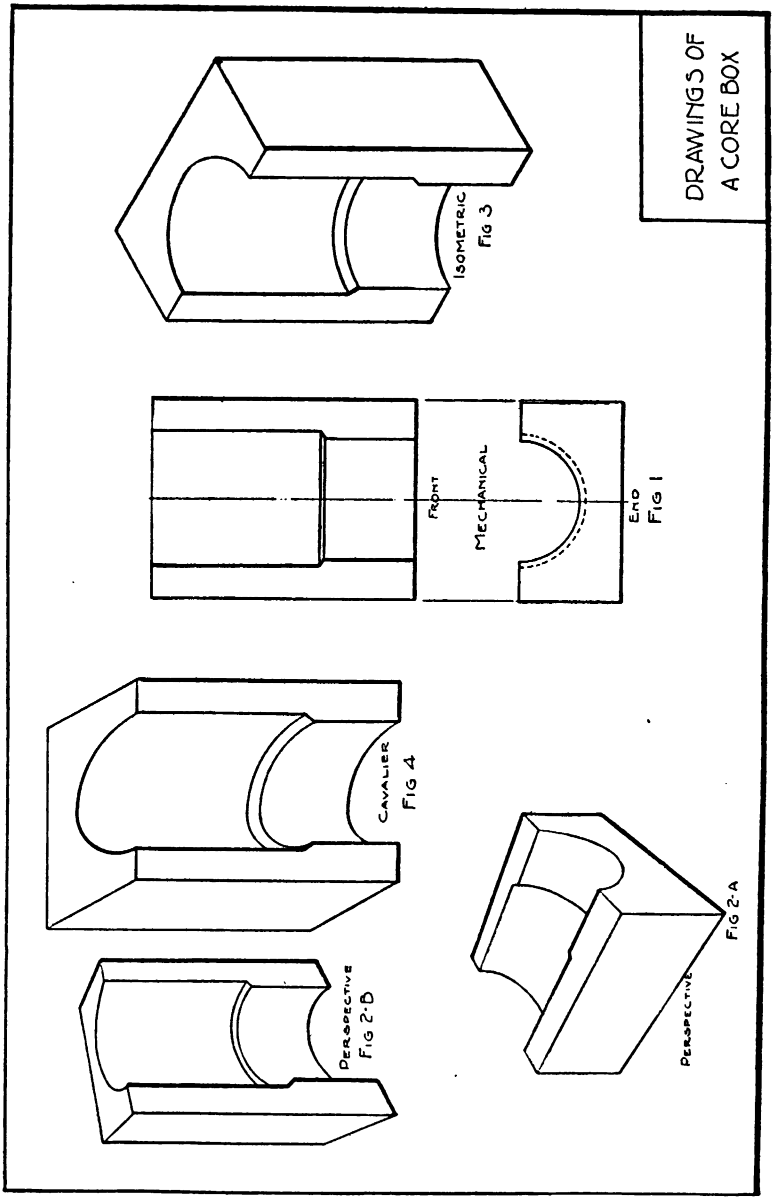

DRAWINGS OF
A CORE BOX
ISOMETRIC
FIG 3
FRONT
MECHANICAL
END
FIG 1
CAVALIER
FIG 4
PERSPECTIVE
FIG 2·A
PERSPECTIVE
FIG 2·B

PLATE No. 1.

ing, Isometric Drawing, and Cavalier or Cabinet Projection or Drawing.

Mechanical Drawing is the art of drawing each separate face of an object just as it is and not as it appears, and arranging the several drawings so as to show the relation of the faces one to the other; Perspective Drawings are the same as pictures, and show the object as it appears from a definite viewpoint; Isometric Drawing is a kind of mechanical-perspective, or picture; and Cavalier Projection, a kind of mechanical-isometric-perspective drawing.

Plate No. 1 illustrates the four kinds of drawings, Fig. 1 being a two-view mechanical drawing, Fig. 2 (*A* and *B*) a perspective drawing, Fig. 3 an isometric drawing, and Fig. 4 a cabinet drawing. The mechanical drawing requires two views to show the object (a part of a core box), while the perspective drawing (Fig. 2 *A*), shows it in one view.

In the mechanical drawing all parallel lines of the object are drawn parallel; in the perspective drawing three faces of the object are shown in one view; in the isometric drawing three faces of the object are shown in the one view, and all parallel lines of the object are shown parallel in the drawing; in the cabinet drawing one face of the figure is drawn as in the mechanical drawing, all parallel lines of the object are parallel in the drawing, as in isometric drawing, and the figure shows three faces in one view, the same as the perspective drawing.

While it is true that one must have a knowledge of mechanical drawing in order to make an isometric drawing, the very opposite is true as to the reading of the two drawings, as one with no knowledge whatsoever of the principles of mechanical drawing is able to readily read an isometric drawing. A perspective drawing is easily read by all, but it is hard to make unless one is more or less of an artist at free-hand work; an isometric drawing is easily made and readily read by all.

3. Uses of the Art.

Being familiar with the principles of mechanical drawing, the reader is also acquainted with the wide field for the use of

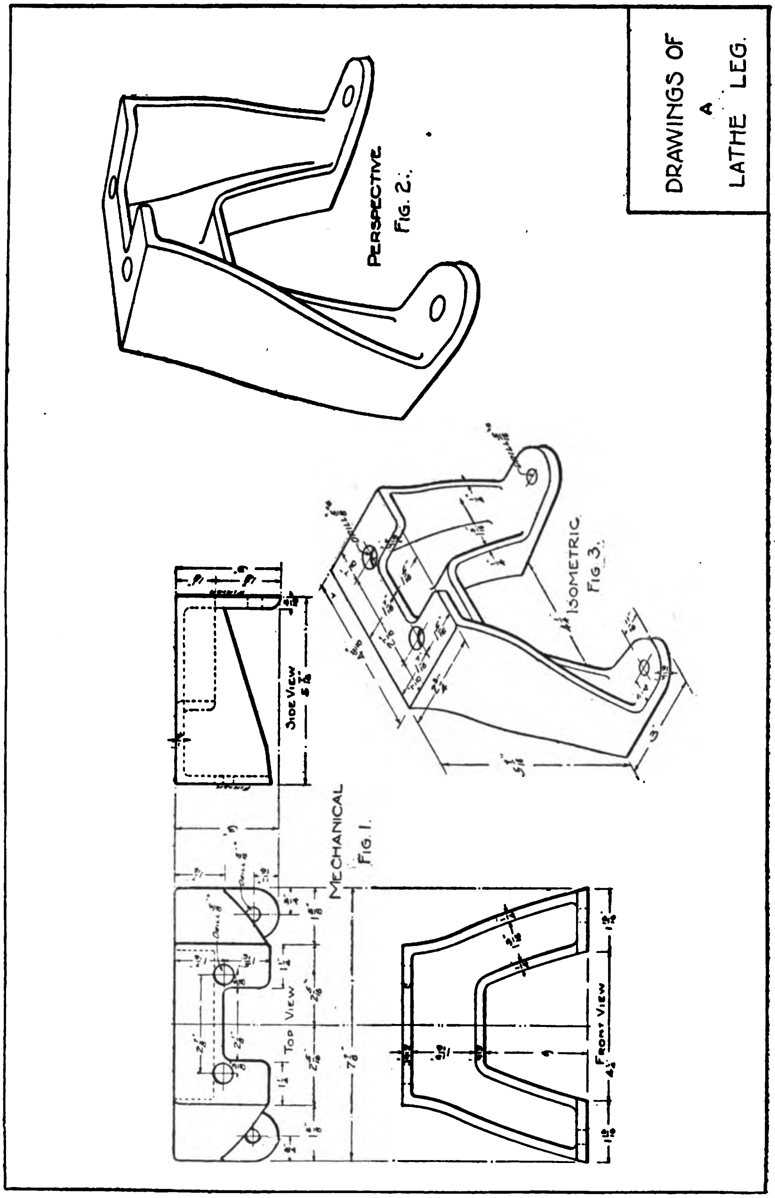

DRAWINGS OF
A
LATHE LEG.
PERSPECTIVE
FIG. 2.
ISOMETRIC
FIG. 3.
MECHANICAL
FIG. 1.
SIDE VIEW
TOP VIEW
FRONT VIEW

PLATE No. 2.

such drawings, for manufacturing and erecting purposes, in the shop and in the field, in books and catalogues, etc. Perspective drawing is not much used in engineering drawing, its field being practically limited to architectural work. It is often desirable to "picture" a machine or machine part or other object, and because of its adaptability it is here that isometric drawing finds its use.

Plate No. 2 illustrates a three-view mechanical drawing of a bench-lathe leg, a perspective drawing of the leg, and an isometric drawing of the leg. A mechanical drawing is primarily a working drawing and lends itself to dimensioning; a perspective or isometric drawing is primarily an illustration or picture and is, in most cases, difficult to dimension. In fact, a perspective drawing can hardly be said to lend itself to dimensioning at all; an isometric drawing will permit dimensioning, though it is seldom done.

Because of its similarity to perspective drawing and of the manner of execution, isometric drawing is sometimes called "Mechanical Perspective." Examples of its use are shown as follows:

Fig. 1 [1] is a copy of an illustration appearing in the *Proceedings of the American Society of Mechanical Engineers* (Vol. 29, page 172), and is one of four similar cuts illustrating a paper on the "Cost of Heating Store-houses."

Fig. 2 [2] is a copy of an illustration appearing in a catalogue issued by a manufacturing company of their metal lumber, showing the framing of a house with their product.

Fig. 3 is an isometric drawing detailing the entrance to a building.

Fig. 4 is a "bird's eye" view of an athletic field showing the enclosing wire fence, the bleachers and grandstand, the foot-ball and base-ball fields, and the running track.

It is for such work as is illustrated by the just mentioned

[1] Reproduced by permission of the American Society of Mechanical Engineers and of Mr. H. O. Lacount, Boston, Mass., author of the paper mentioned.

[2] Reproduced by permission of the Berger Manufacturing Company, Canton, Ohio.

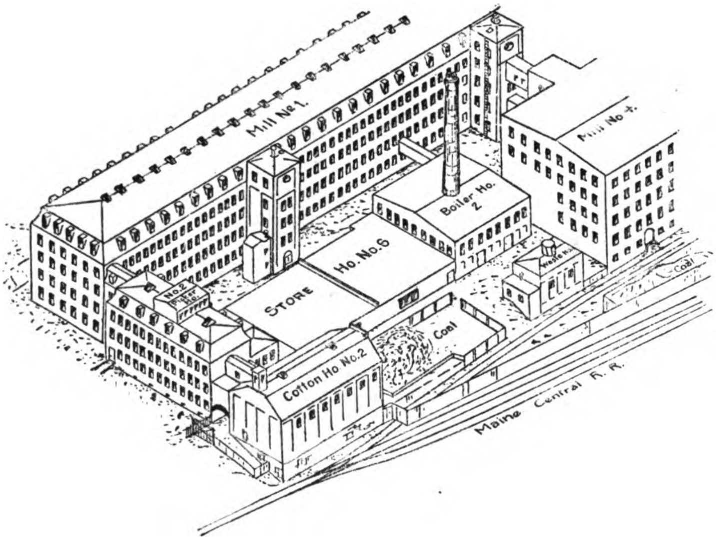

Mill No 1.
Mill No 4.
Boiler Ho. 2
Ho. No. 6
STORE
No. 2
Cotton Ho. No. 2
Coal
Maine Central R. R.

Fig. 1.

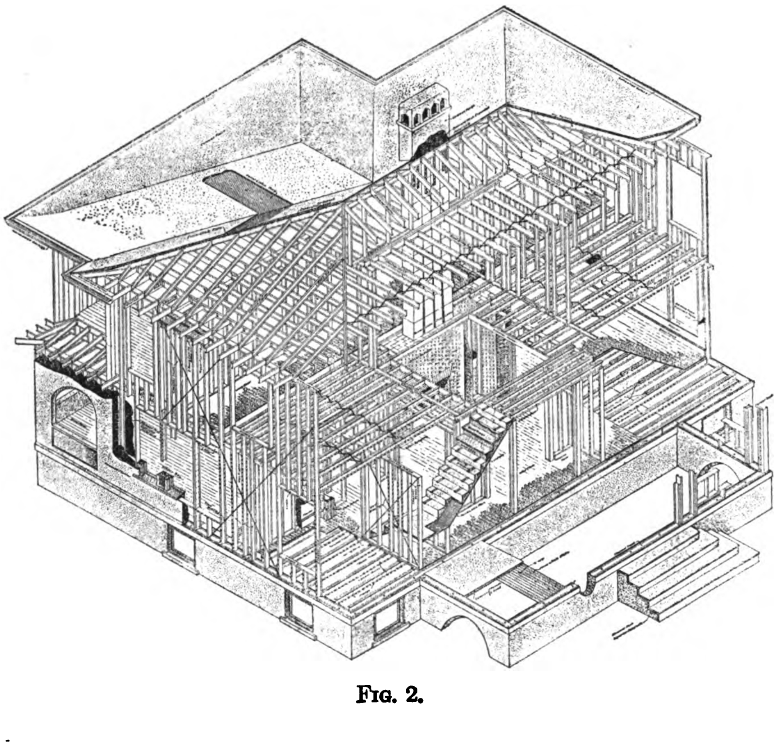


Fig. 2.

figures that isometric drawing finds its ready and best use, that is, in drawings where most of the lines are straight lines

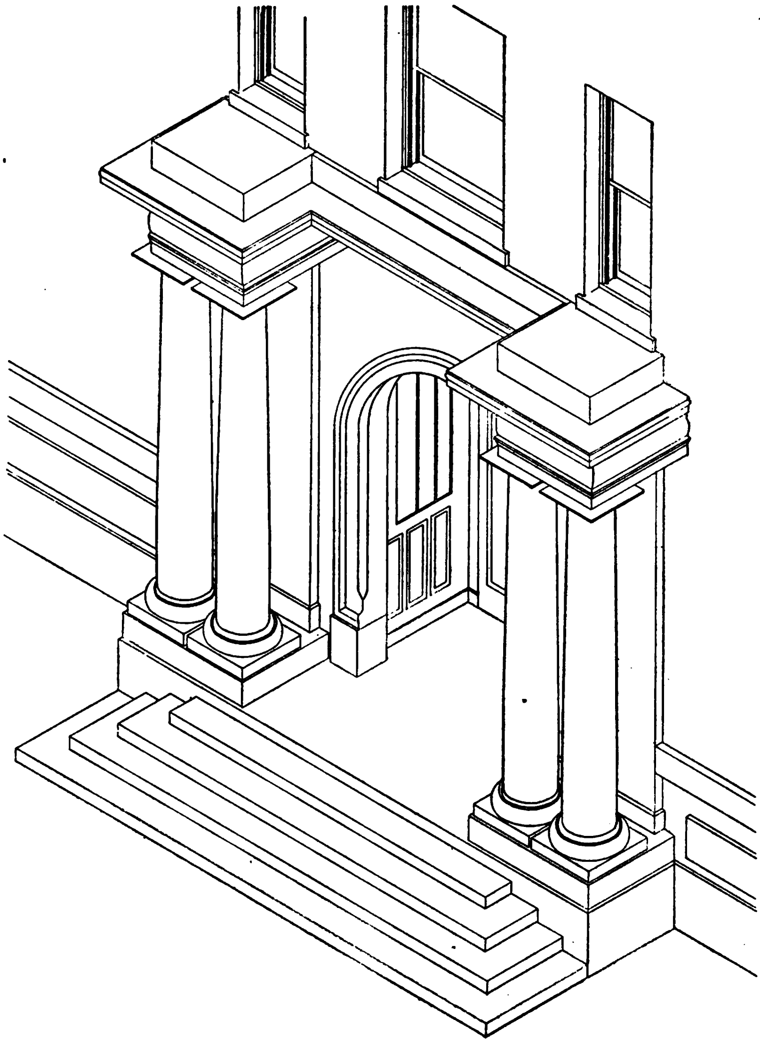


FIG. 3.

and the objects drawn are of a rectangular character. It is possible, however, to draw many kinds of irregular objects, as is evidenced by the illustrations of the text.

4. Time Element.

While isometric drawing is limited to certain uses because of the nature of the object and the purpose of the drawing, the real, practical limitation to the art is the time required to execute the drawings.

The author has on several occasions made comparison of the time required in which to draw a mechanical drawing and the time consumed in making an isometric drawing; he has timed himself, and has taken the time of a number of students, and finds that, with the exception of very simple rectangular objects, it requires more time to make an isometric drawing

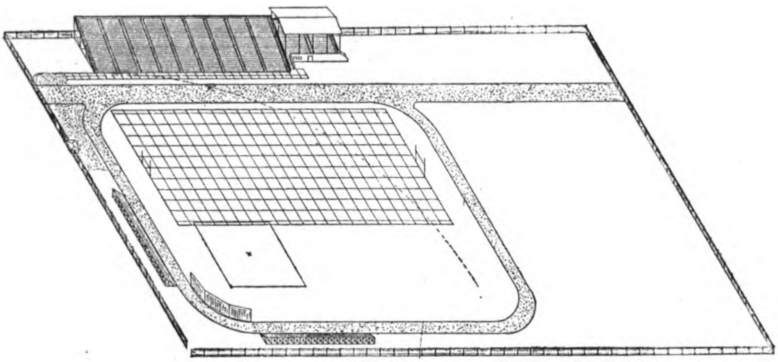


FIG. 4.

than it does to execute a mechanical drawing—the increase in time required depending entirely upon the nature of the object.

For some very simple objects it was found that an isometric drawing could be made in a little less time than that required for making a mechanical drawing; for a large number of simple rectangular objects, with few curves and circular holes or cylindrical parts, it was found that the time required for the two kinds of drawings about balanced; as the object drawn became more complex, having cylindrical and curved members, nuts, threads, etc., to draw, the time required varied from 30 to 200 per cent more time for isometric drawings than for straight mechanical drawings, the average being about 80 per cent.

In general, therefore, it may be said that isometric drawing requires from 50 to 100 per cent more time for its execution than mechanical drawing. Of course, some objects will require several hundred per cent more time; but it is surprising, in the field for which it is best adapted and for the purpose for which the drawing is most used, how many illustrations may be made with isometric drawings with but very little increase in time taken over that required for making a mechanical drawing.

5. Characteristics.

It has been stated (Article 1) that isometric drawing has but two principles. Such a statement is speaking broadly, and

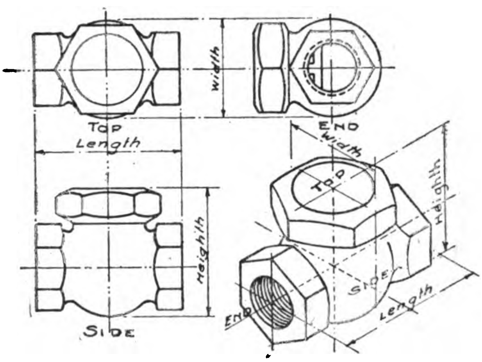


FIG. 5.

should be further qualified by adding, " which are new to one already familiar with the principles of mechanical drawing."

Isometric drawing is based on isometric projection, and isometric projection is the result of a particular kind of projection and has a certain definite underlying principle. This work being an exposition of the " How " of the art, the development and the further explanation of the theory are purposely omitted.

In mechanical drawing the center lines, dimensions, and reference lines are drawn horizontally and vertically, and a view is given for illustrating each face of the object drawn; in isometric drawing the center lines, dimensions and reference lines are drawn at an angle with the horizontal and vertical, and three faces are shown in one view or drawing. The two characteristics of isometric drawing, as compared with ordinary mechanical drawing, are, therefore, the direction of the principal lines and the showing of the three dimensions of an object in one view. (See Fig. 5.)

6. Tools Used.

The tools required for making isometric drawings are practically the same as those needed for ordinary mechanical

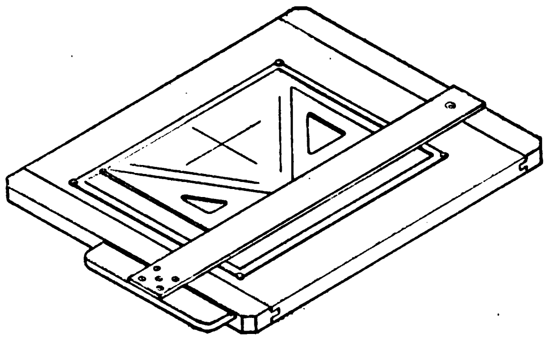


FIG. 6.

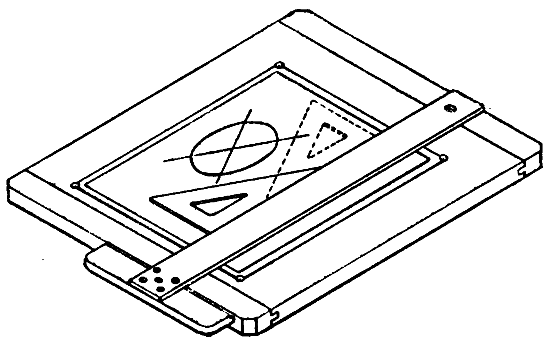


FIG. 7.

drawing (Fig. 6), the only difference being in the triangles. The principal lines in isometric drawing are either horizontal, vertical, or 30° or 60° to the horizontal, and are drawn with the 30°–60° triangle and T-square, the 45° triangle so much used in mechanical drawing being dispensed with (Fig. 7).

All of the figures given in the text can be drawn in pencil with the following tools: A drawing board; a T-square; a 30°–60° triangle; a pencil compass; an irregular curve; and the necessary paper, pencil, and scale or ruler. To ink the drawings requires the usual pens and ink.

7. Center Lines and Axes.

An object has three dimensions, namely, length, width or breadth, and height or thickness. In mechanical drawing two of these dimensions show in any one view, but it requires a second view to give the third dimension. In isometric drawing three dimensions are given in one view.

In laying out a mechanical drawing it is the usual practice to work to some reference line. This line is usually a center line, and is either horizontal or vertical. When two center lines are used, they are drawn at right angles one to the other. This method is also used in isometric drawing.

Fig. 8 is an isometric drawing of three planes, *a–b–c–d* and *e–f–g–h* being vertical planes and *i–j–k–l* a horizontal plane. A pair of center lines are shown drawn on each plane, the lines 5–5 and 6–6 being on the horizontal plane and the lines 3–3, 4–4, 1–1, and 2–2 being on the vertical planes. They are shown in the conventional manner at *A*, *B*, and *C*, respectively. All of these center lines, regardless of the plane in which they lie, would be shown in mechanical drawing, as illustrated at *D*.

The three planes shown are those most usually assumed in drawing, and it is important that the reader note the characteristics of the three sets of lines, as these lines determine the plane of the drawing. The lines shown at *A* are at 30° with the horizontal, are drawn with the T-square and 30° triangle (the 30° angle of the 30°–60° triangle), and are characteristic center lines for use when drawing on a horizontal plane. The lines shown at *B* are drawn, one vertical and one at 30° with the horizontal (with the T-square and 30° triangle), and are characteristic center lines for use when drawing on what may be termed a left-hand vertical plane. The center lines shown at *C* are drawn, one vertical and one at an angle of 30° with the horizontal, and are characteristic center lines for use when drawing on what may be termed a right-hand vertical plane.

When drawing in any one of the above three planes the drawing is limited to two dimensions only—plane figures; to represent objects with three dimensions—solids—a third principal line of reference is used, called an axis. The dashed lines shown at *A*, *B*, and *C* of Fig. 8 represent such lines, and, as

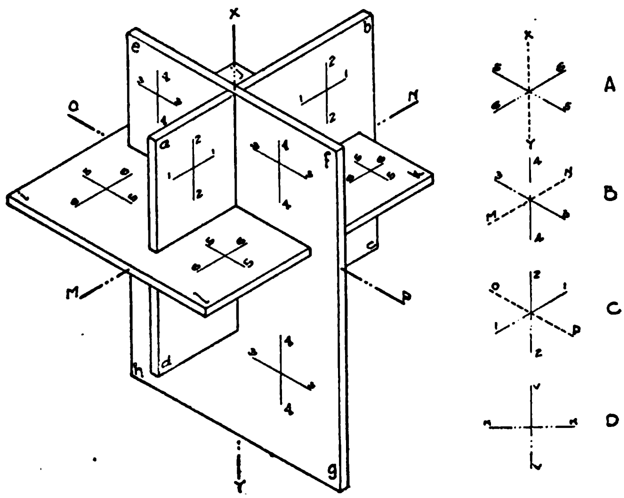


FIG. 8.

in the cases *A*, *B*, and *C* mentioned above in connection with characteristic center lines, are characteristic axes for isometric drawings.

8. Flexibility.

The center lines and axes just described are the basis or base lines for all isometric drawing, and as long as the relation between the three lines as shown in Fig. 8 is maintained they may be drawn at will. For practical purposes the direction of the lines is determined by the drawing tools used, the T-square and triangle. The four usual arrangements are shown at *a*, *b*, *c*, and *d* of Fig. 9.

Being thus able to select a number of directions for drawing the axis of a drawing, isometric drawing permits an object to be shown in a number of different positions, as illustrated at

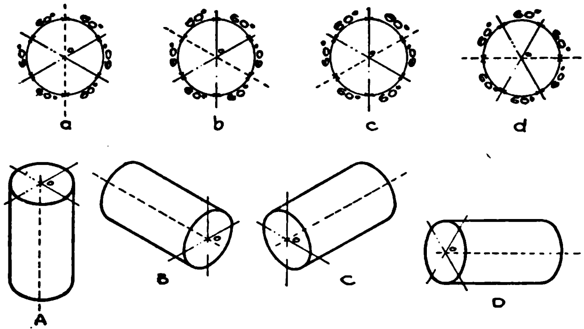


Fig. 9.

A, *B*, *C*, and *D*, Fig. 9, and at *B*–1, *B*–2, *B*–3, *B*–4, *B*–5, Fig. 39.

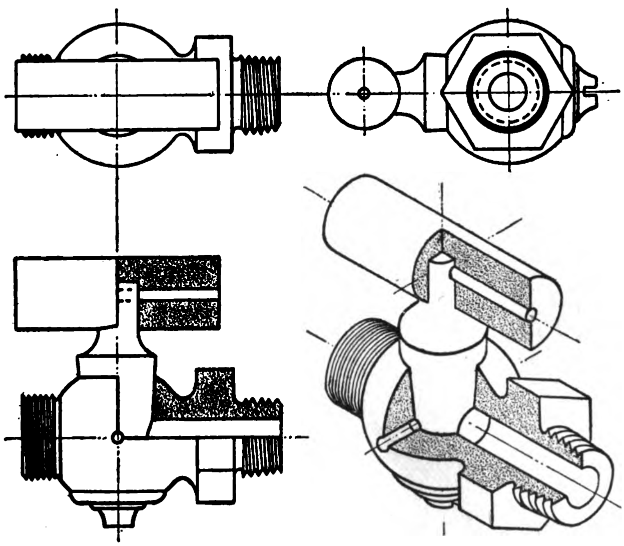


Fig. 10.

In addition to being able to show an object in different positions, sections may be shown in isometric drawings the same as in ordinary mechanical drawing.

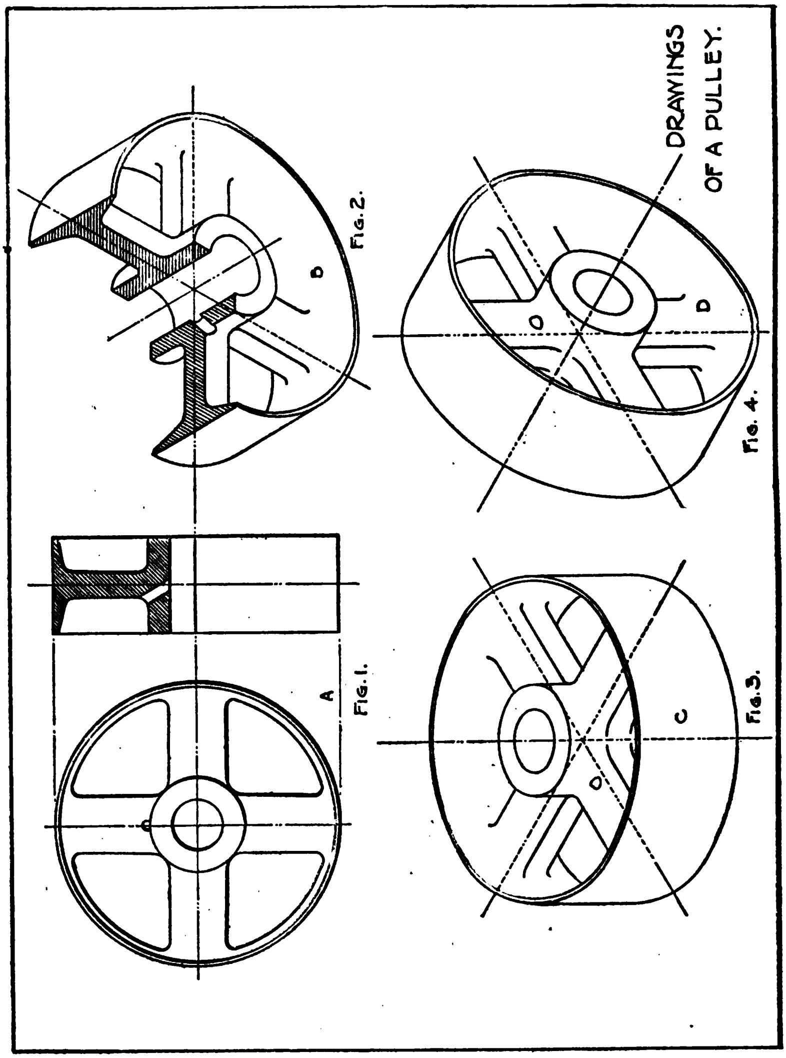


PLATE NO. 3.

Plate 3 illustrates the flexibility of the art: Fig. 1 is a two-view mechanical drawing of a loose pulley, the face view showing a half section; Fig. 2 is an isometric drawing of the pulley, showing the same section removed as in Fig. 1; and Figs. 2, 3, and 4 show the pulley in different positions.

Fig. 10 is a three-view mechanical drawing of an indicator cock or valve, and an isometric drawing of the same valve. The drawings show a section of the valve removed to show the interior.

Plate 3 and Fig. 10, together with the other illustrations of the text, serve to demonstrate the flexibility of the art.

CHAPTER II

THE DRAWING OF PLANE FIGURES

9. To Draw a Square.

Fig. 11 illustrates a square drawn in different positions, drawing *A* being a mechanical drawing and drawings *B*, *C*, and *D* isometric drawings. Drawing *B* represents the square as lying on the horizontal plane; and drawings *C* and *D* as lying on vertical planes.

To construct the square (consider drawing *B*), draw the center lines 5–5 and 6–6 with the T-square and 30° triangle, each line being at 30° with the horizontal. Next, assuming the square to be 1″ on a side and working from the intersection of the center lines, *o*, lay off, each way from the point *o*, on each center line, a distance of ½″, or one-half of the length of a side of the square, and locate the points 6, 6 and 5, 5.

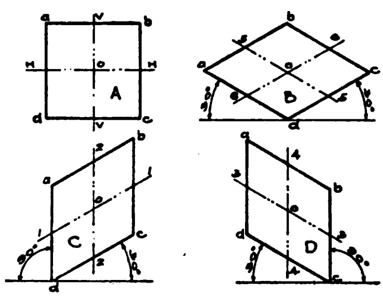


Fig. 11.

Lastly, draw through each of the two points on each center line a line parallel to the other center line; these lines will meet and will form the required figure, *a–b–c–d*, as shown.

Drawings *C* and *D* are drawn in like manner, the only difference being in the direction of the center lines, which may, however, be drawn, as before, with the T-square and 30°–60° triangle.

10. To Draw a Hexagon.

Fig. 12 represents the drawing of a hexagon, drawing *A* being a mechanical drawing, and drawings *B*–1, *B*–2, *C*, and *D* isometric drawings. Of the isometric drawings, *B*–1 and *B*–2 are on horizontal planes and drawings *C* and *D* on vertical planes.

In mechanical drawing the drawings are always drawn square with the center lines, as shown at *A*, and not as shown at *E*; this custom prevails because of the better appearing drawings produced and because of the greater convenience and speed secured when executing the drawing. This method of drawing things square with the center lines is followed in isometric drawing.

To construct the hexagon (consider drawing *B*–2), first draw the center lines 5–5 and 6–6 at the angle shown. Now

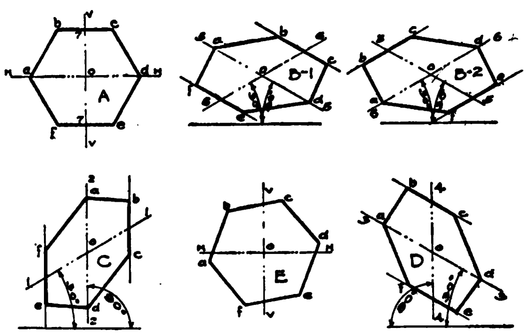


FIG. 12.

a hexagon has two so-called diameters or dimensions, namely, the distance between opposite sides or flats, as distance 7–7, drawing *A*, and the distance between opposite corners, the diagonal distance, as distance *a–d*, drawing *A*. Second, working each way from the intersection of the two center lines, *o*, lay off one-half of the diagonal distance on one center line, and one-half of the flat distance or dimension on the other center line. This gives the points *a*, *d*, 5, and 5, respectively, Third, draw lines through the points obtained by laying off the flat diameter of the hexagon, the points 5 and 5, and on each line lay off, each way from the point through which the line is drawn, one-half of the length of a side of the hexagon. This gives the points *b*, *c*, *e*, and *f*. Fourth, and lastly, connect the six points now located, as shown, giving the required figure. [See also Article 13, (*d*) and (*e*).]

11. To Draw an Octagon.

Fig. 13 shows an octagon—a mechanical drawing of the figure at *A*, an isometric drawing on a horizontal plane at *B*, and isometric drawings on vertical planes at *C* and *D*.

The figure may be constructed in two ways:

First method (consider drawing *C*).

Draw the center lines 1–1 and 2–2. On these center lines construct the "square of the octagon," *b–d–f–h*, as shown, and as explained in Article 9. Next, working from the intersection of the center lines, *o*, lay off each way on each center line, one-half of the diagonal distance or diameter of the octagon. This gives the points *a*, *c*, *e*, and *g*. Lastly, join the eight points, as shown, and form the octagon.

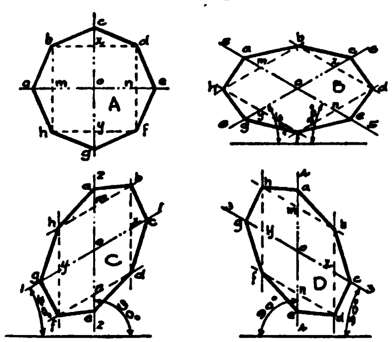


FIG. 13.

Second method (consider drawing *D*).

This method is by referring all of the points to the center lines. In drawing *A*, consider points *a*, *b*, *c*, *d*, *e*, *f*, *g*, and *h* projected (perpendicularly) onto the center lines, giving on center line *c–g* the points *c*, *x*, *o*, *y*, and *g*, and on line *a–e* the points *a*, *m*, *o*, *n*, and *e*. To draw the isometric drawing *D*, first draw the center lines as shown, and, working from point *o*, lay off on each the corresponding above-mentioned projected points; that is, on line *a–e*, lay off points *a*, *m*, *o*, *n*, and *e*, and on line *c–g* points *c*, *x*, *o*, *y* and *g*. Second, through the points *x* and *y* on line *c–g* draw indefinite lines (such as lines *b–x–d* and *h–y–f*) parallel to center line *a–e*. Third, draw indefinite lines through the points *m* and *n* on center line *a–e* parallel to center line *c–g*. These two lines will intersect the pair first drawn and will locate points *b*, *d*, *f*, and *h*. The points *a*, *c*, *e*, and *g*, being on the center lines, are fixed, and, to finish the figure, connect the eight points found, as shown.

When an octagon on a horizontal plane lies within a circumscribing circle, the construction of the figure is much simplified thereby. In such a case, Fig. 14, first draw the center lines 5–5 and 6–6. Second, draw the circumscribing circle (the construction of a circle is given in Article 13). Third, draw a horizontal and a vertical line through the intersection of the center lines, point *o*. Fourth, and lastly, join the eight points in which the center lines and the last drawn two lines cut the circumference of the circle.[1] It is obvious that a similar construction can be applied when drawing on a vertical plane

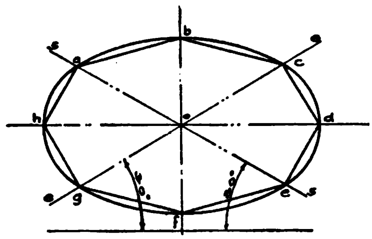


FIG. 14.

12. To Draw Any Polygon.

Fig. 15 represents the construction of a ten-sided figure and of a fifteen-sided figure, and is typical of any polygon. The method shown is what may be called "plotting," and is based on the reference of all points to the center lines. In any plane figure each and every point has two dimensions, so to speak. For example, a point is so far from each of the two center lines; in drawing *A*–1, point *c* is *c*–5 (or 4–*o*) distance from the vertical center line, and *c*–4 (or 5–*o*) distance from the horizontal center line. Now if these distances are known, they may be laid off on the center lines, a line drawn through the point on one center line parallel to the other center line, and the point located by the intersection of the lines drawn.

To construct the fifteen-sided figure:

In drawing *A*–2, project all of the points onto the vertical center line (giving points *a*, 15, 16, 17, *o*, 18, 19, 20, and 21), then all onto the horizontal center line (giving points 1, 2, 3, 4, 5, 6, 7, *o*, 8, 9, 10, 11, 12, 13, and 14). Second, draw the iso-

[1] The isometric drawing of a circle is an ellipse, but is spoken of as a "circle."

metric center lines *a*–21 and 1–14 (drawing *B*–2), and, working from their point of intersection, *o*, lay off the points *a*, 15, 16, 17, *o*, 18, 19, 20, and 21 on the line *a*–21 and the points 1, 2, 3, 4, 5, 6, 7, *o*, 8, 9, 10, 11, 12, 13, and 14 on the line 1–14. Third, draw lines through the points on line *a*–21 parallel to line 1–14, then lines through the points on line 1–14 parallel to line *a*–21. The intersection of the two lines drawn through the point on each of the two center lines obtained (at the start) by the projection of any corner onto the center lines, locates the point in question, and the series of lines the several points *a*, *b*, *c*, *d*, etc. Lastly, join the points as shown.

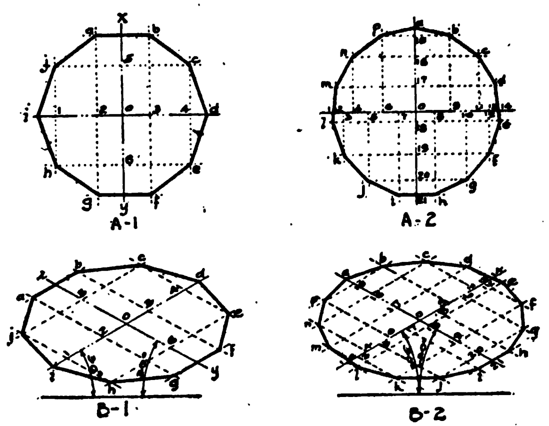


FIG. 15.

In cases where the necessary dimensions for executing the drawing cannot readily be obtained from the object, it is necessary to first construct a mechanical drawing of the part or detail in question, to draw the center lines of the figure, and to project the point or points on these lines (as in drawings *A*–1 and *A*–2); then take up the isometric drawing, using the distances or dimensions thus obtained for its construction.

13. To Draw a Circle.

Figs. 16 and 17 are drawings of a circle, and represent two methods of construction.

(*a*) *First method.*

Fig. 16 illustrates the mechanical drawing of a circle (drawing *A*) and the isometric drawing of a circle (drawings *B, C* and *D*), drawing *B* being on a horizontal plane and drawings *C* and *D* on vertical planes.

To construct the figure (consider drawing *B*), first draw the center lines *a–b* and *c–d*, each at 30° with the horizontal. Second, working from the intersection of the two center lines, *o*, lay off on each center line, each way from point *o*, a distance equal to the radius of the circle. This gives points *a, b, c,* and *d.* Third, through each of the two points on each center line draw a line parallel to the other center line. These four lines will form a diamond-shaped figure (a parallelogram), 1–2–3–4.

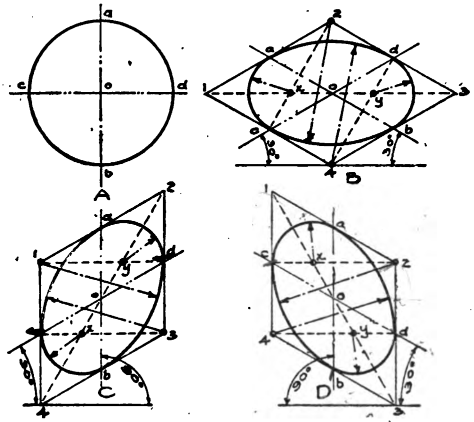


FIG. 16.

Fourth, with the point 2 as a center and the distance from the point to the middle of the opposite side of the parallelogram, distance 2–*c*, as a radius, describe the arc *c–b*. Fifth, with the point 4 as a center and a radius equal to the distance from the point to the middle of the opposite side of the parallelogram as a radius, distance 4–*d*, describe the arc *a–d*. Sixth, draw the diagonal of the parallelogram, the line 1–3, and where this line intersects the lines 2–*c* and 4–*d*, the points *x* and *y*, take new centers and, with a radius equal to the distance from either point to the middle of the nearest sides of the parallelogram such as distances *x–c* or *y–d*, draw the arcs *a–c* and *b–d*, completing the ellipse *a–d–b–c*—the isometric representation of the circle.

The ellipse or "circle" in drawing *C* or *D*, the plane of which is vertical, is drawn in a manner similar to that just described. The method just explained is an approximate method.

(*b*) *Second method.*

Fig. 17 illustrates a second method of constructing an isometric drawing of a circle. In the figure, drawing *A* is a mechanical drawing and drawing *B* an isometric drawing. The method shown is similar to that employed in Fig. 15 and described in Article 12, and is what has been termed plotting.

To construct the figure, first draw the mechanical drawing of the circle (*A*), divide the circumference into any number

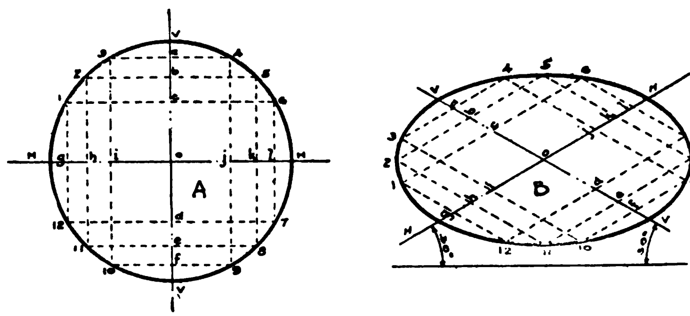


FIG. 17.

of points, project these points onto the center lines, then take up the isometric drawing. In this (drawing *B*), the center lines are drawn; the points of division, *V*, *a*, *b*, *c*, *o*, etc., obtained by the projection of the points of division of the circle onto the center lines (drawing *A*), laid off; lines drawn through the points of division as shown; the points 4, 5, 6, etc., located by the intersection of the lines; and the closed curve *V*, 4, 5, 6, etc., obtained by drawing a smooth curve through the points found—all as suggested and shown by the figure.

The method just described is an exact method.

(*c*) *Error cf the first method.*

The two methods given for making an isometric drawing of a circle are shown applied in Fig. 18, the circle (so called) *a–b–c–d* being drawn by the first, or approximate, method, and the circle *a–e–b–f–c–g–d–h* drawn by the second, or exact, method.

An inspection of the figure shows that the approximate method gives a representation which is shorter and wider than

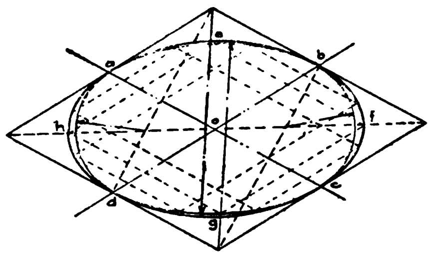


FIG. 18.

that obtained by the exact method. The approximate method, being the easier of application, is the one used practically, and because of its two errors sometimes leads to slight complications in the construction of drawings; for example, when the circle joins or fits into or about some other figure or part, as when drawing a sphere, a circumscribing or inscribed circle, etc.

Fig. 19 illustrates a circle drawn by the two methods already given, the dotted curve being drawn by the approximate method and the full-line curve by the exact method; also, the drawing of a hexagon, in two positions, about the true circle (Article 10). The particular points to be noted in this figure are that in either hexagon the length of each of the two sides which are parallel with one of the center lines (*a–b* and *d–e* or *h–i* and *k–l*) is the true length of a side of the hexagon, and that each of these two lines (*a–b* and *d–e*, or *h–i* and *k–l*) is symmetrical with the center line (being divided into two, *a–b* and *d–e* at *H*, and *h–i* and *k–l* at *V*).

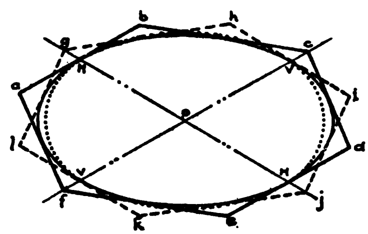


FIG. 19.

Fig. 20 illustrates a circle drawn by the approximate method, and an inscribed (the dashed-line figure) and a circumscribed (the full-line figure) hexagon. The dotted hexagon A'–B'–C–D'–E'–F is a correct drawing of the circumscribed hexagon without reference to the circle and shows, at the corners A', B', D', and E', the error of a hexagon drawn with reference to a circle drawn by the approximate method.

The particular feature to note in this figure is that in the hexagon the two sides (A–B and D–E or a–b and d–e, which are drawn parallel with the center line V–V, are unsymmetrical with the center line H–H, being longer on one side (H–B and H–E or h–b and h–e) than on the other (A–H and H–D or a–h and h–d).

The convenience of the approximate method for drawing a circle, and the large number of circles and circular arcs always to be drawn more than outweigh the errors (such as described above) introduced by its adoption and application. In cases where a discrepancy shows up, it will be but slight, and it is customary and an easy matter to adapt the lines so as to make the conditions fit.

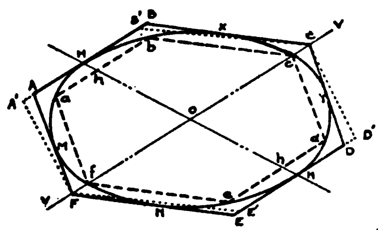


Fig. 20.

(*d*) *To draw an inscribed hexagon.*

To draw a hexagon within a circle (Fig. 20), first draw the circle by the approximate method [Article 13 (*a*)]. Where the center line V–V cuts the circle, points c and f, locates two points of the hexagon. Second, working from point o, lay off on the center line H–H, each way from o, one-half of the distance between sides of the hexagon, the length o–h, and draw through each of the two points thus obtained a line parallel to the center line V–V. Where these lines cut the circle, points a, b, d, and e, locates four points of the hexagon. Third, join the six points found, and the hexagon a–b–c–d–e–f is obtained.

(*e*) *To draw a circumscribed hexagon.*

To draw a circumscribed hexagon (Fig. 20), first draw the isometric representation of the circle by the approximate method. Second, working from the point *o*, lay off on the center line *V–V*, each way from *o*, one-half of the distance between corners of the hexagon (the lengths *o–C* and *o–F*). This locates two points (*C* and *F*) of the hexagon. Third, through each of the points *H*, in which the center line *H–H* intersects the ellipse *H–X–Y–H*, etc., draw a line parallel to center line *V–V*. Fourth, from the points *C* and *F* draw lines, each way, tangent to the circle (points *X*, *Y*, *M*, and *N*) intersecting the lines drawn through the points *H* parallel to line *V–V*. The intersection of these lines locates the remaining four corners of the hexagon, and the construction completes the drawing of the figure.

(*f*) *To draw a series of uniform circles the centers of which lie in the same straight line and plane.*

Fig. 21 illustrates a number of uniform circles with centers in a common straight line, drawing *A* being a mechanical drawing and drawing *B* an isometric drawing.

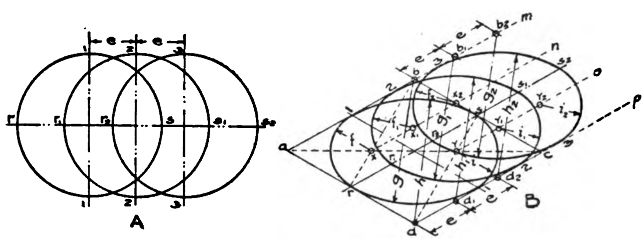


FIG. 21.

To construct the isometric drawing, first consider one circle only, as, for example, the circle *r*–1–*s*–1 of drawing *A*, and draw the isometric representation of this circle by the approximate method [Article 13 (*a*)], as shown in drawing *B* by the parallelogram *a–b–c–d*, the radii *f*, *g*, *h*, and *i*, and the ellipse *r*–1–*s*–1. Second, extend the center line *r–s*, the lines *a–b* and *d–c*, and through the points X and Y draw lines parallel to the above lines, all as shown by the line s–s_2 and the dashed lines *b–m*, *c–p*, X–*n* and Y–*o*, respectively. Third, lay off on the line *d–p* the distances d–d_1, and d_1–d_2 equal to the length *e*, the distance between centers of the circles; and, with a radius equal to radius *h* and the points d_1, d_2 as centers, describe the arcs 2–s_1

and $3-s_2$ (parallel to the arc $1-s$). Fourth, locate the points b_1 and b_2 in like manner and, with these points as centers and a radius equal to radius g, draw the arcs r_1-2 and r_2-3 (parallel to the arc $r-1$). Fifth, lay off on the line $x-n$ the distances $x-x_1$ and x_1-x_2 equal to the length e, the distance between centers of the circles and, with the points x_1 and x_2 as centers and a radius equal to radius f, draw the arcs $2-r_1$ and $3-r_2$. Sixth, and lastly, locate the points Y_1 and Y_2 in a similar manner and, with these as centers and a radius equal to the radius i, draw the arcs $2-s_1$, and $3-s_2$, completing the figure.

A considerable amount of labor of construction is eliminated by keeping the above scheme in mind, and it is offered to call attention to the fact that there are many such "short cuts" which will become apparent after some little practice in the art, and which should always be taken advantage of.

14. To Draw an Ellipse.

Fig. 22 illustrates the drawing of an ellipse. *A* is the mechanical drawing, and *B* the isometric drawing. The isometric drawing is shown on a vertical plane.

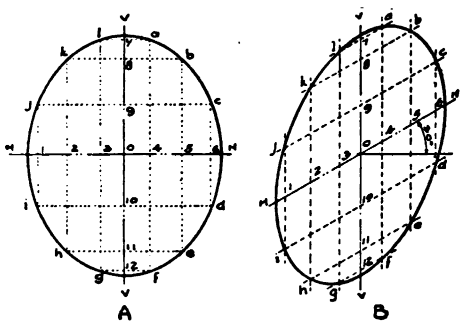


FIG. 22.

To draw the figure, first divide the ellipse as drawn at *A* into a number of points, as points *a*, *b*, *c*, etc.; then project the points onto the center lines as shown by the points 1, 2, 3, 4, etc. Second, draw the center lines *H–H* and *V–V* of drawing *B*, and on them lay off the corresponding divisions on the center lines of drawing *A*, points 1, 2, 3, 4, etc. Third, through the divisions on each center line draw lines parallel to the other center line. The point in which the lines through the two points on the center lines (one on each) representing the projection of any one point intersect, will locate that particular point, and the series of lines the several points *a, b, c,* etc. Fourth, and lastly, through the points thus obtained and the points *H, H* and *V, V,* the ends of the axes of the ellipse, draw the curve *H, a, b, c,* etc., the isometric drawing of the ellipse.

15. To Draw an Hyperbola.

Fig. 23 illustrates an hyperbola. Drawing *A* is the mechanical, and drawing *B* the isometric drawing. The feature of this figure is that it has but one center line (line 1–*e*) and introduces the use of a second line of reference which may be called a base line (line 5–12).

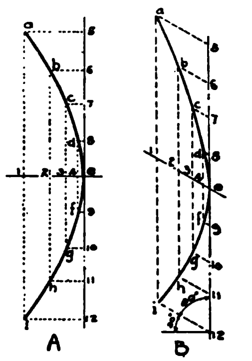


Fig. 23.

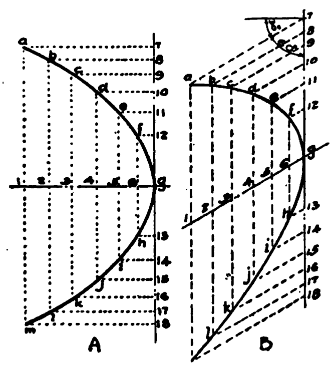


Fig. 24.

To draw the figure, first divide the curve into a number of points, as points *a, b, c,* etc., of drawing *A*; then project each point into the center line and onto the base line, thus obtaining the points 1, 2, 3, etc. Second, draw the center line 1–*e* and the base line 5–12 of drawing *B,* and on them lay off the points 1, 2, 3, etc. Third, draw lines through each of these points as shown and locate the points *a, b, c,* etc. Fourth, through the points thus located draw the curve *a, b, c,* etc., the isometric drawing of the hyperbola.

16. To Draw a Parabola.

Fig. 24 illustrates two drawings of a parabola, drawing *A* being a mechanical drawing and drawing *B* an isometric drawing.

The construction is the same as described in Article 15, and is clearly shown by the figure.

17. To Draw an Undulating Figure.

It will have been noted that most of the figures given thus far are shown drawn on the horizontal plane, Figs. 17, 18, 19, 20, and 21, for example, and that the last three, Figs. 22, 23 and 24, are drawn on vertical planes. This is done to acquaint the reader with the flexibility of the art (Article 8), and to illustrate the procedure on the two planes. To further illustrate the choice of position or plane in which to draw, Fig. 25 is offered. It illustrates the drawing of an undulating figure made up

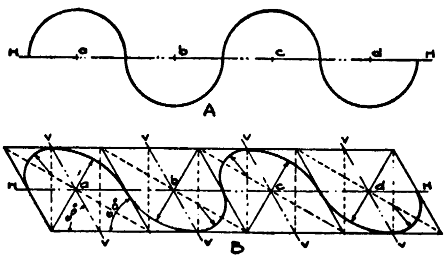


FIG. 25.

of semicircles, and shows the drawing on what may be termed an oblique plane the center lines for which agree with those illustrated in Fig. 9 at *d*.

To draw the figure, draw the horizontal line *H–H* and on it lay off the points *a*, *b*, *c*, and *d*, a distance apart equal to the distance between centers of the circular arcs as shown in drawing *A*. Second, through each point draw a center line *V–V* at 60° with the horizontal. Third, on each pair of center lines, such as *H–H* and *V–a–V*, lay out the necessary lining and construct a semicircle as described in Article 13 (*a*), and, as shown by the figure, the series of semicircles will form the required figure.

18. To Draw Any Figure Composed of Straight Lines and Circular Arcs.

Fig. 26 illustrates the drawing of a figure made up by a combination of straight lines and circular arcs. The isometric drawing *B* is on a vertical plane, and the construction very similar to that described in Article 17.

To construct the figure, first draw the center line *H–H* at 30° with the horizontal, and on it lay off the center points *a, b, c,* and *d,* corresponding to the center points *a, b, c,* and *d* of drawing *A*. Second, through each point draw a center line *V–V,* and on each pair of center lines thus formed proceed with the lay-out for drawing a circle by the approximate method (Article 13), and obtain the centers and radii necessary to describe the arcs of the figure—all as illustrated. Lastly, connect the circular arcs with straight lines as shown.

Combinations of straight lines and circular arcs are very frequent in drawing and it is important that the draughtsman

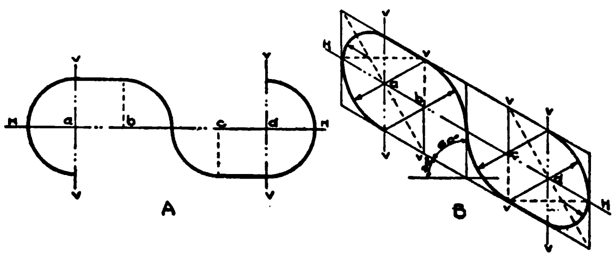


FIG. 26.

know how to treat them. Sometimes they are in such a form that a beginner does not recognize or think of them as such. One of the examples most frequently met with is the representing of round corners of figures and objects.

Fig. 27 illustrates a square with rounded corners. It will be noted from an inspection of the figure that the arcs at the corners are circular arcs, and that they may be continued to form complete circles and the figures to come under a construction as given for Fig. 26.

To construct the isometric drawing *B,* first draw the center lines *H–H* and *V–V,* and construct the square *W–X–Y–Z* (Article 9). Second, consider the lower left-hand corner of the figure, *W,* and from the corner lay off, each way, a distance equal to radius *R,* as lengths *W–f* and *W–e*; through the points thus obtained, points *f* and *e*, draw the center lines *f–f* and *e–e*. Third, working to the center lines just found, use the approximate method for drawing a circle (Article 13), and locate the center point *o* and the radius *r*, and describe the full-line arc *f–e*, that portion of the ellipse *f–e–f–e* forming the rounded corner in question. Fourth, in a similar manner draw in the full-line curve *a–b* at corner *X*, as shown by the drawing.

The curves at corners *Y* and *Z* may be obtained in a similar manner, though with a little less work. That is, now that the scheme is known, in applying the method for drawing a circle, only that portion of the entire construction used for the drawing

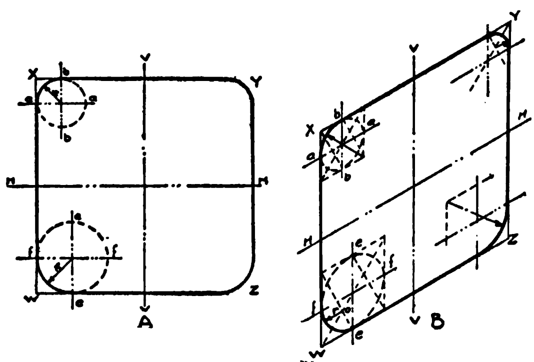


FIG. 27.

of a circle needed to locate the center point and the necessary radius need be drawn, the construction being clearly shown in the figure.

19. The Proper Arrangement of All Drawings with Reference to the Center Lines, and the Manner of Laying Off Dimensions.

It will have been noticed that all of the constructions given thus far begin with the drawing of the two center lines, and that the figures then drawn are drawn square with the center lines. Also, that the dimensions are all laid off on the center lines, or on lines parallel to the center lines. This is the correct practice in isometric drawing, and is but in strict accordance with the usual and accepted practice in ordinary mechanical drawing.

Fig. 28 shows at drawings *A* and *A*–1 the usual placing of a hexagon with reference to the center lines; drawing *A*–2 shows an unusual arrangement. When such an arrangement is to be drawn in isometric, the corners of the hexagon must be referred to the center lines and the points located by plotting, as directed in Article 12, and as shown by drawing *B*–2.

It may be well to note the four right angles formed by the center lines in drawings *A*–2 and *B*–2. The angle 7–*o*–1 of drawing *A*–2 is shown as 7–*o*–1 of drawing *B*–2 (note that this angle as drawn is more than a right angle, but in isometric drawing is used as and called a right angle), and the angle 7–*o*–6 of drawing *A*–2 is shown at *B*–2 as the angle 7–*o*–6 (note that this angle as drawn is less than 90°, but is used as and called a right angle). The other two angles are readily noted in the figure.

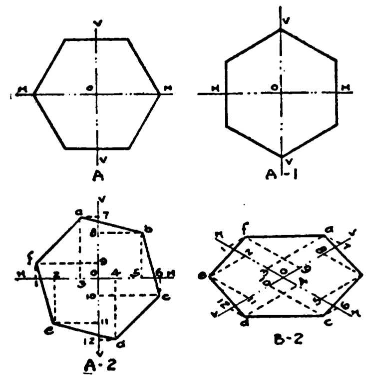


Fig. 28.

In mechanical drawings the two dimensions of plane figures are always either vertical or horizontal; in isometric drawing one dimension is sometimes vertical and sometimes horizontal (never one horizontal and the other vertical), and when it is so the other dimension is always at an angle to the horizontal or vertical (see Article 8), the arrangement depending upon the arrangement of the center lines of the figure in question.

It should be remembered, therefore, to always lay off dimensions parallel with the center lines of the figure drawn, and when measuring an isometric drawing to scale it in directions parallel with the center lines.

CHAPTER III

THE DRAWING OF SOLIDS

20. Preparatory.

The student is cautioned not to attempt the reading of this chapter without first reading Chapter II and mastering, in so far as possible, the principles and methods there set forth. The drawing of solids is based on the drawing of plane figures, and the only new feature introduced in this chapter is the drawing on different planes, not as set forth in Article 8 and as illustrated by the figures of Chapter II, exactly, but the drawing on all of the planes mentioned, possibly in the same illustration, with a definite relation as to position to all of the other planes.

If one has a thorough knowledge of the methods given in Chapter II, the only difficulty likely to be encountered when making isometric drawings of solids is to get the drawing of any particular feature of the object drawn on the correct plane. This is the one difficulty which is of serious moment to the beginner, and requires some little experience and practice to eliminate. To reduce such trouble to a minimum the student should carefully consider the part in question, note the plane (horizontal or vertical) on which it lies, then note the center lines of the plane of his drawing. If the center lines are drawn as set forth in Article 7, the correct plane can always be established.

A second, minor, difficulty often encountered is to get the correct position of the plane on which to draw. This is a matter of dimension and lay-out, and the difficulty can only be eliminated by the student's keeping in mind that all dimensions must be laid out along lines which are parallel with the center lines or axis of the figure or drawing.

Coming now to the drawing of solids, the drawings have three dimensions, and use is made of the third of the three lines mentioned in Article 7 (the axis) and illustrated in Fig. 8 at *A, B,* and *C,* and Fig. 9 at *a, b, c,* and *d.* These three lines are the basis of all of the constructions which follow.

21. To Draw a Rectangular Block.

Fig. 29 is an illustration of a rectangular block, drawing *A* being a mechanical drawing and drawings *B, B*–1, and *B*–2 isometric drawings. The isometric drawings show the block in three different positions, also three different constructions. All of the constructions are simple, but should be considered. They are:

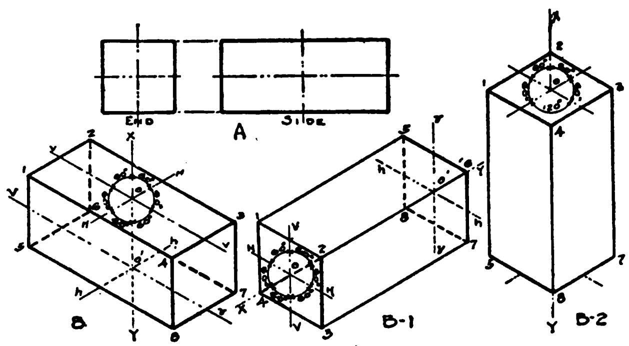


FIG. 29.

1. To construct drawing *B*, first draw the center lines *H–H* and *V–V*, and on them construct the rectangle 1–2–3–4 as explained in Article 9, the size of the rectangle to agree with the dimensions of the top face of the block. Second, draw the line *X–Y* (the axis for the center lines *H–H* and *V–V*, Article 7) and on it lay off a length *o–o′* equal to the thickness of the block. Third, through the point *o′* draw the center lines *h–h* and *v–v*, and working to these construct the rectangle 5–6–7–8. Fourth, and lastly, join the points 1 and 5, 2 and 6, etc., completing the figure as shown.

2. To construct drawing *B*–1, first draw the center lines *H–H* and *V–V* and on them construct the face 1–2–3–4. Second, draw the axis for the center lines just used, line *X–Y*, and on it lay off the length of the block and locate the point *o′*. Third, through the point *o′* draw center lines, and working to them

construct the face 5–6–7–8. Fourth, join the corners of two bases as shown.

3. To construct drawing *B*–2, first draw the face 1–2–3–4 as in the second construction. Second, through the points 1, 4, and 3, draw lines parallel to the axis of the block, and on them lay off lengths equal to the length of the block. This locates points 5, 8, and 7. Third, join the points 5 and 8, and 7 and 8.

22. To Draw a Pyramid of Blocks.

Fig. 30 illustrates a number of square blocks, piled one upon the other in such a manner as to keep the pile symmetrical.

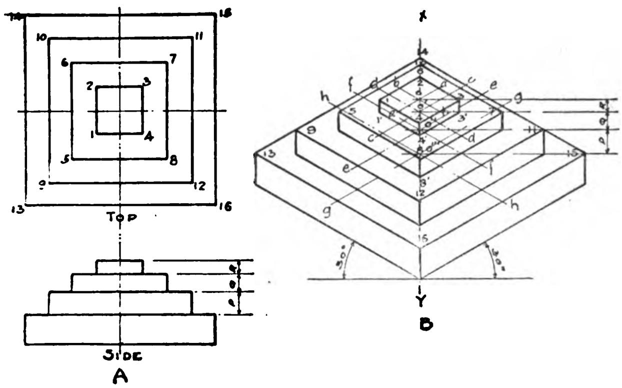


FIG. 30.

To construct the isometric drawing (*B*), first draw the center lines *a–a* and *b–b*, and on them construct the square 1–2–3–4, as explained in Article 9. Second, from the corners 1, 3, and 4, drop vertical lines, and on the line through the point 4 lay off a length 4–4′ equal to the thickness of the block. Third, through the point thus located (point 4′) draw the lines 4′–3′ and 4′–1′ parallel to the center lines *a–a* and *b–b*, respectively. Fourth, through the intersection of the center lines, point *o*, draw the axis *X–Y*, and on it lay off a length equal to the thickness of the top or smallest block. Fifth, through the point thus located, point *o*′, draw the center lines *c–c* and *d–d*; working to them construct the square 5–6–7–8 and finish the drawing of the outline of the second block, all in a manner similar to the drawing of the first block. Sixth, establish the plane of the top of the third block by dropping down from point o' to o'' a distance equal to the thickness of the second block and drawing the center lines *e–e* and *f–f*, and construct the outline of the third block as shown. Seventh, proceed in a similar manner for the construction of the fourth block, and complete the figure.

23. To Draw an Hexagonal Prism. Fig. 31 illustrates the construction of an hexagonal prism.

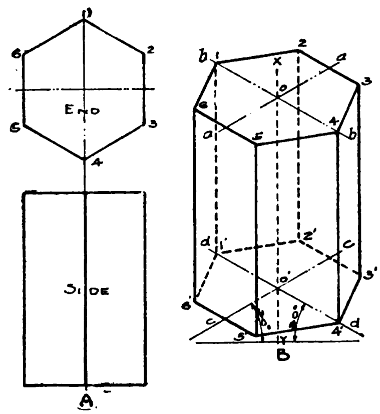


FIG. 31.

To construct the figure, first draw the center lines *a–a* and *b–b*, and on these construct the hexagon 1–2–3–4–5–6, as explained in Article 10. Second, draw the axis of the figure, the line *X–Y*, and on it lay off a length o–o' equal to the length of the prism. Third, through the point o' draw the center lines *c–c* and *d–d*, and working to them construct the hexagon 1′–2′–3′–4′–5′–6′. Fourth, join the corners of the two bases as shown, completing the figure.

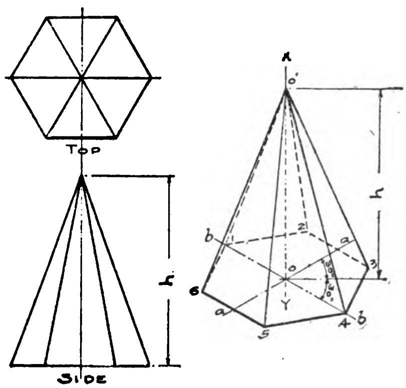


FIG. 32.

24. To Draw an Hexagonal Pyramid.

Fig. 32 illustrates the construction of an hexagonal pyramid.

To construct the figure, first draw the center lines *a–a* and *b–b*, and working to them construct the hexagon 1–2–3–4–5–6 as directed in Article 10. Second, draw the axis *X–Y*, and from the point o lay off a length o–o' equal to the height of the pyramid. Third, join each corner of the hexagon with the point o'.

25. To Draw Any Rectangular Solid which is of Uniform or Similar Section.

Fig. 33 is an illustration of a clamp block, and is, like the objects illustrated in Figs. 29 and 31, uniform in section, and is drawn in a similar manner.

To construct the figure, first draw the center lines a–a and b–b. Second, working from the point o, lay off, each way, the lengths o–4, 4–3, etc., corresponding to the widths of the object as defined in drawing A. Third, working from point o, lay off the lengths o–r and o–s, as shown, corresponding to the thickness of the block. Fourth, through the points on each center line draw lines parallel to the other center line; the intersection of these two sets of lines will locate all points of the end face of the object, which may be drawn by joining the points as shown. Fifth, draw the axis X–Y and on it lay off, from point o, a length o–o' equal to the length of the block. Sixth, through the point o' draw the center lines c–c and d–d, and working to them draw the outline of the rear face of the block. Seventh, connect the two faces by joining the corners, and complete the figure, as shown.

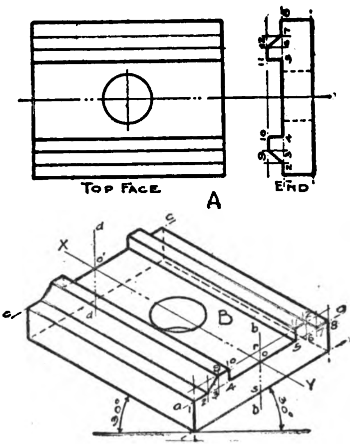


FIG. 33.

Attention is called to the similarity of the above construction of the visible end face to that given for drawing any polygon, Article 12. It is as much "plotting" as the method there described. Also, note that the center lines used are not, exactly, what are usually termed center lines. The point to be noted is that the method or scheme for executing the construction of all figures is similar, and that center lines may be used as base or reference lines.

From Figs. 29, 31, and 33 it may be taken as a general construction for all objects which are uniform in section, to first construct the two ends or bases, then join the bases properly, forming the sides and completing the figure.

Fig. 34 illustrates two objects which taper from one end to the other, objects of which a section at any point is similar to a section at any and all other points. Drawing *A* is a mechanical drawing of a crank blank, drawing *B* its isometric representation, and drawing *C* an isometric drawing of a steel key.

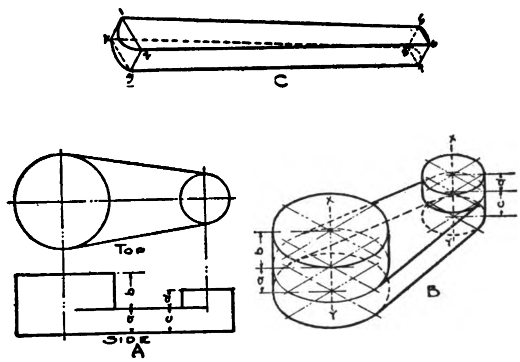


FIG. 34.

The method for constructing such figures is similar to that used when the section of the object drawn is uniform; that is, to first draw the two ends (end sections), then join the two as may be necessary to finish the figure.

For example, to draw the steel key shown at *C*, first draw the end section 1–2–3–4; second, the end section 5–6–7–8; and, third, join the sections as shown.

The illustration of the crank is offered to show a very different type of model from those given thus far, namely, objects of a rectangular nature; but it will be noted that the treatment or method of construction of the drawing is the same. To construct drawing *B*, first establish the three sets of center lines of the large end, as when drawing the pyramid of blocks

(Article 22), and working to them construct the three ellipses (Article 13) shown. Second, proceeding in a similar manner, construct the three ellipses of the small end of the figure. And, third, join up the two ends with tangent lines, as shown.

26. To Draw Any Rectangular Solid of Variable Section.

Fig. 35 is an illustration of a draughtsman's pencil-pointing pad, the handle of which varies in width. The construction of the drawing of this part of the object demonstrates a method of procedure applicable to the representation of any rectangular object of variable section.

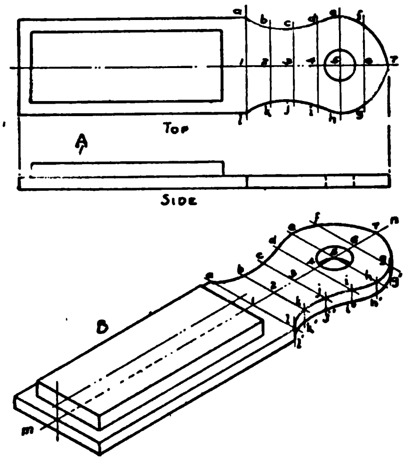


FIG. 35.

The rectangular part of the figure (drawing *B*) is drawn in a manner similar to that illustrated in Fig. 30 and described in Article 22. To construct the drawing of the handle, first draw the center or base line, *m–n*. Second, divide this line into a number of parts (such as by a point every ½″ or ¼″, or by taking points at places where the section of the object drawn changes) by marking off points such as points 1, 2, 3, etc. Third, through each point draw a line at right angles (so called in isometric drawing) to the line *m–n* (note that the line through any point is but a second center line), and on each line lay off, each way from the point on the line *m–n*, a length equal to one-half of the width of the handle at that point, obtaining the points *a*, *b*, *c*, *d*, etc. Fourth, through the points thus located draw the curve, the outline of the handle, as shown. To draw the bottom curve, the line defining the thickness of the handle, draw vertical lines *j–j′*, *i–i′*, etc., through the points *j*, *i*, etc., and on each line lay off a length equal to the thickness of the handle, locating points j', i', etc., and draw through these points as shown.

The above example happens to be such that the curves drawn (on the top plane) are symmetrical with the center line m–n; should the case be different, a base line may be used for reference and from it the construction can be laid out, but the method is similar to that just described.

27. To Draw a Cylinder.

The drawing of a circle is given in Article 13, and the drawing of a solid of uniform section in Article 25, the drawing of a cylinder is based on these two constructions.

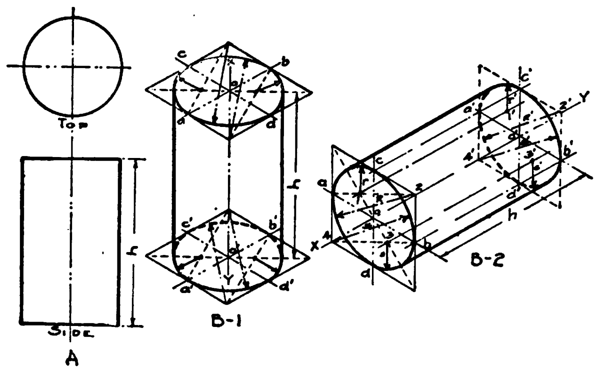


FIG. 36.

Fig. 36 is an illustration of a right cylinder, drawing A being a mechanical drawing and drawings B–1 and B–2 isometric drawings.

To construct drawing B–1, first draw the center lines a–b and c–d, and in accordance with Article 13 construct the ellipse of the upper base. Second, draw the axis of the cylinder, the line X–Y, and on it lay off the length o–o' equal to the length of the cylinder. Third, at the point o' establish the plane of the lower base by drawing the center lines a'–b' and c'–d' and construct the ellipse a'–c'–b'–d'. Fourth, draw vertical lines tangent to the two bases, completing the figure.

To construct drawing B–2, first draw the center lines a–b and c–d, and draw the ellipse representing the near end of the cylinder in accordance with the above reference and as shown by the centers 1, 2, 3, and 4, and the radii *R, S, r,* and *s*. Second, shift the center points 1, 2, 3, and 4 along the lines 1–1′, 2–2′, etc. (parallel to the axis *X–Y*), a distance equal to the length of the cylinder, and, with the new position of the center points, points 1′, 2′, 3′, and 4′, as centers and the same radii as used to draw the front end of the cylinder, draw the rear end, as shown. Third, draw lines tangent to the two bases.

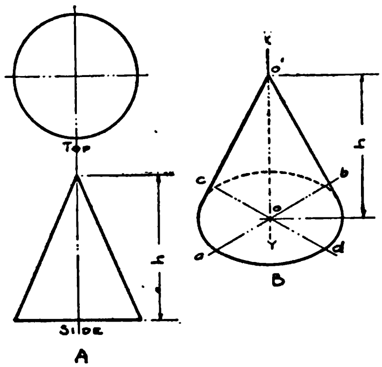


Fig. 37.

28. To Draw a Cone.

Fig. 37 illustrates the construction of a cone.

To construct drawing *B*, first draw the center lines *a–b* and *c–d*, and working to them describe the ellipse *a–c–b–d* (Article 13) of the base. Second, through the point *o*, draw the axis of the cone, the line *X–Y*, and on it lay off a length *o–o′* equal to the altitude or height of the cone. Third, from the point *o′* draw lines tangent to the base.

29. To Draw a Solid Made Up of Circular Arcs and Straight Lines.

Very often an object will have a number of curves which are circular arcs. When such is the case, the construction is similar to that described in Article 18.

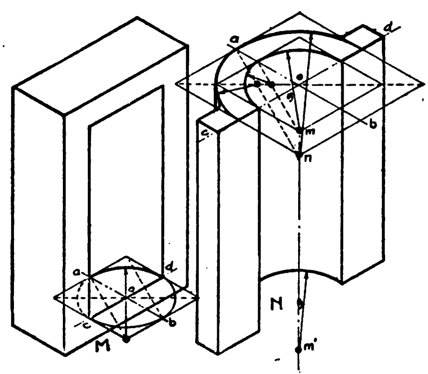


Fig. 38.

Fig. 38 illustrates the isometric drawing of two objects the lines of which are either straight lines or circular arcs. Drawing *M* represents a core box, and drawing *N* a cap for a bearing.

To draw the circular arc showing at the bottom of the core box (arc *a–d*), consider the arc as extended to complete the circle of which it is a part; then lay out the construction for drawing a circle (Article 13), locate the center point and the radius for describing that portion of the ellipse covered by the arc in question (in this case, one-fourth of the circumference), and draw in the required curve.

The drawing of the bearing cap is offered as a second example of the application of the above method of drawing parts of circles, and the construction, which is clearly shown in the figure, should be carefully noted.

Attention is called to the arc at the bottom of the figure; this arc is drawn by dropping the point *m* to *m′* a length equal to the length of the object, and, with this new point as a center, and a radius *s*, the same radius used to draw the corresponding arc at the top, drawing it in, as shown.

30. To Draw a Ring, Rectangular in Section.

Fig. 39 illustrates the drawing of a ring which is rectangular in section. Drawing *A* is a mechanical drawing and drawings *B*–1, *B*–2, *B*–3, *B*–4, and *B*–5 are isometric drawings. The several isometric drawings are given to illustrate the choice of view or position of the object open to the draughtsmen.

The figure should be compared with Fig. 9, and the similarity of position of the center lines and axis of the various drawings noted. For example, the position *B*–1 corresponds to position *d* of Fig. 9, *B*–3 to *b*, and position *B*–5 to position *c*. The positions *B*–2 and *B*–4 have no corresponding position shown in Fig. 9, but it will be noted that the relation of the lines used as center lines and axis is the same as in all isometric drawing, that is, adjacent lines forming an angle of 60°, as shown.

The construction of the several drawings is identical, and is illustrated in drawing *B*–1. To construct this drawing, first draw the center lines *a–b* and *c–d*, and working to them lay off, each way from the point *o*, a length equal to the radius of the inside of the ring, locating the points 1, 2, 3, and 4. Second, through these points draw the figure *e–f–g–h*, and within this the ellipse 1–2–3–4, all as directed for drawing the representation of a circle in isometric, and as shown. Third, working to the same center lines, since the two circles of the end face are in the same plane, proceed in a similar manner and construct the ellipse 5–6–7–8. Fourth, draw such portions of the right end face of the ring as are visible, and finish the figure by drawing the two outside lines (top and bottom) tangent to the two bases.

The lines of the drawing show every line of the construction. Attention is again called to the short method employed for

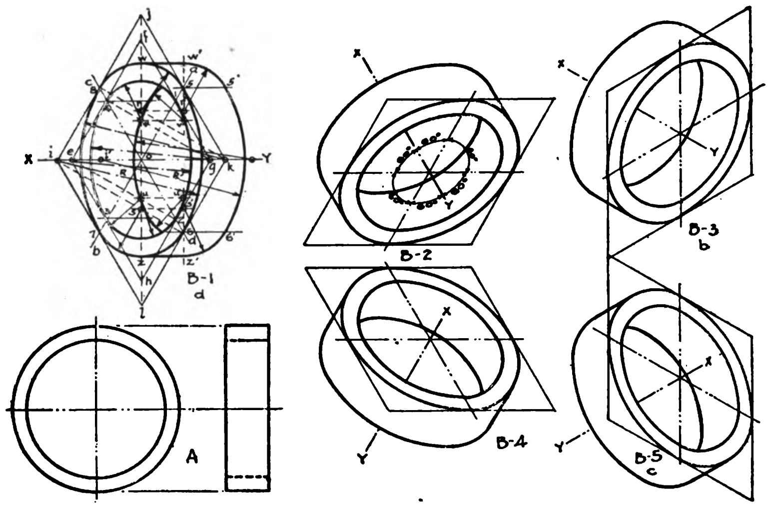


Fig. 39.

drawing the arcs of the ellipses showing in the rear base or end of the ring. For example, consider the outside curve at the rear, the line *w′*–5′–6′–*z′*; this curve is parallel to the curve *w*–5–6–*z* of the front face. To draw the arc at the rear, first draw through the points 5 and 6 the guide lines 5–5′ and 6–6′ parallel to the axis (line *X*–*Y*) of the ring. Second, draw a similar line through the point *i*, and on it lay off a length *i*–*i′* equal to the thickness or length of the ring, and, with the point thus located, the point *i′*, as a center and a radius *R′* equal to radius *R*, describe the arc 5′–6′. Third, in like manner shift the center point r to r', and s to s', and, with the new position of the points as centers and the same radius as used for the corresponding arc of the front face of the ring, describe the arcs $5'$–w' and $6'$–z', thus finishing the arc entire.

31. To Draw a Circular Disc with Holes in it.

Fig. 40 is an illustration of a disc with three equally spaced countersunk holes in it.

To construct the figure, the disc may be considered as a short cylinder and its outline drawn accordingly (Article 27), the

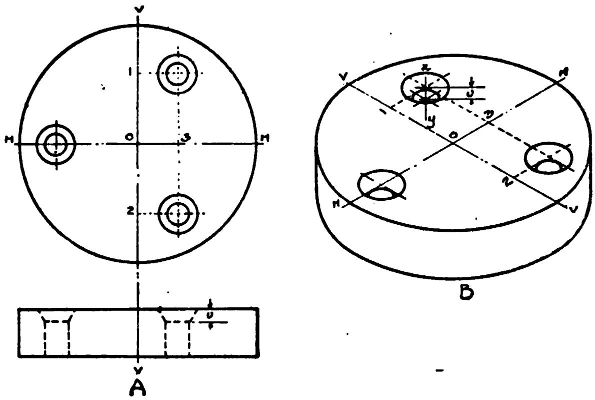


FIG. 40.

center of the holes located by reference to the center lines of the top face of the disc, the planes of the circles representing the outline of the countersunk hole located as shown in Fig. 30 and explained in Article 22, and the ellipse defining the holes drawn as explained in Article 13.

The new feature introduced by this figure is the location and drawing of the countersunk holes. On the contrary, however, the so-called "new feature" is not new, as the construction is only the application of methods already known. The feature is an ever-recurrent one, and it is important that the student understand the method of procedure.

Since it is correct practice to draw things square with the center lines when drawing objects such as the disc shown, square as many features with the center lines as possible. For example, if there should be but a single hole in the object, construct the drawing with the center of the hole on one of the center lines; if the object has two holes either 90° or 180° apart, see that they are located on the center lines; if the object has four holes equally spaced, place the centers on the center lines, etc. When there is an unequal number of holes, as in the present case of three, place one of the holes on one of the center lines, and, by plotting, referring the centers to the center lines, locate the centers for the other two holes as shown.

It must always be borne in mind that an isometric drawing is not measured or laid out like a mechanical drawing, but that all dimensions must be laid out or taken in some one of three directions, that is, parallel to either center line or to the axis.

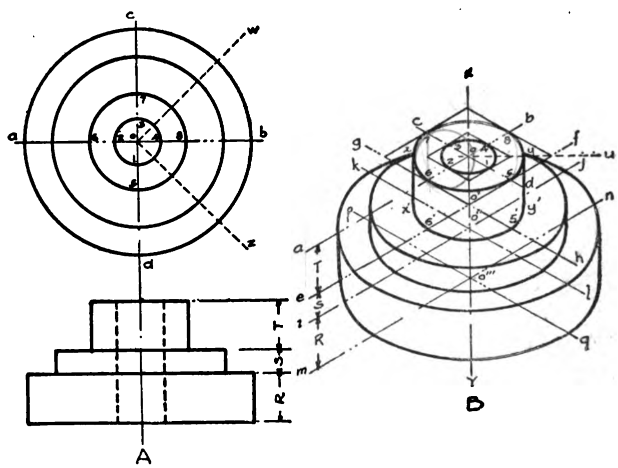


FIG. 41.

32. To Draw a Stepped Pulley.

Fig. 41 is an illustration of a three-stepped cone pulley.

To construct the figure (drawing *B*), first draw the center lines of the plane of the top face, the lines *a–b* and *c–d*, and working to them draw the outline of the hole through the center (Article 13; also see Fig. 42). Second, working to the same set of center lines, in similar manner draw the ellipse 5–6–7–8. Third, drop the three centers used to draw the arc *x*–6–5–*y* a distance equal to the dimension T and, with the same radii used to draw the above curve, draw the arc x'–$6'$–$5'$, all as directed for drawing the cylinder (Article 27) and as explained in connection with the construction of the drawing of the ring (Article 30).

The remainder of the construction is similar to that already given, the procedure being to drop down the axis X–Y distances T, S and R, locate the points o', o'' and o''', establish new planes at these points, and working to the center lines drawn draw in the several ellipses and complete the figure as shown.

33. To Take Out a Section.

In mechanical drawing it is customary when removing a section to remove some portion limited by the center lines. For example, in the case of the stepped pulley, Fig. 41, if a half section is to be shown, the quarter assumed to be removed would not be such a one as is included in the angle *w–o–z* (drawing *A*), but one such as is included in the angle *c–o–b*. This practice holds, also, in isometric drawing, and a section such as would show in the angle *u–o–y* of drawing *B*, Fig. 41, is never given, the correct method being illustrated by Fig. 42.

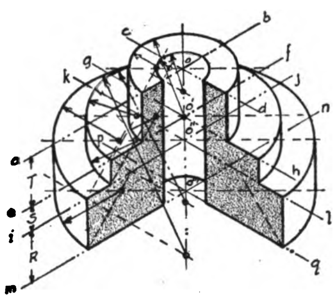


FIG. 42.

Fig. 42 illustrates the usual procedure for drawing an object with a section removed. The lines are all shown, and, in the light of what has been given thus far, the figure should prove self explanatory.

When executing such as the above, two methods may be followed: (1) To first make the construction for the entire figure, then remove the section; (2) To make the construction for only that portion of the object which is to show in the figure. The first construction is the safer for the beginner, and should be followed at first; after some experience the work may be shortened in a number of ways which will then be apparent.

34. To Draw an Eccentric.

Fig. 43 is an illustration of a small eccentric blank. The dimensions are given on the mechanical drawing (*A*) that the student may make the exact construction, should he care to do so. The figure does not introduce anything new, but is given as an example illustrating the inaccuracy of the method used for drawing the isometric representation of a circle.

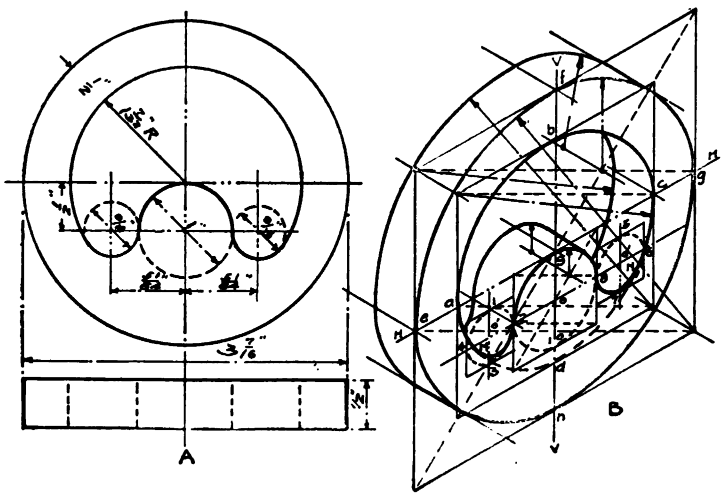


Fig. 43.

The error of the method is discussed in paragraph (*c*) of Article 13, and is illustrated at the points *M* and *N* of drawing *B*, Fig. 43. If the method used were exact, the ellipse *a–b–c–d* and the ellipse 1–2–3–4 would be tangent at the point *M* instead of intersecting; also, the slight discrepancy at point *N* would be eliminated. However, the drawing is but an illustration, and no harm is done when the curves are made to look right by joining them as shown.

The student will, doubtless, encounter many similar conditions in his work. When such cases do occur, adjust the curves to match in such a way as to make the drawing appear natural.

To construct drawing *B*, first consider the outer rim of the eccentric as a ring, and make the construction as directed in Article 30. Second, consider the hub, or center, as a cylinder, and make the construction as in Article 27. Third, locate the points *o′* by dimension, draw the ellipses 1–2–3–4 and 5–6–7–8 as a guide, then adjust the curves to meet the ellipse *a–b–c–d*, as mentioned above.

The figure shows such lines as will suggest the several steps necessary for the construction, showing the particular radii and centers necessary to be shifted to draw the curves at the back, or rear, of the figure.

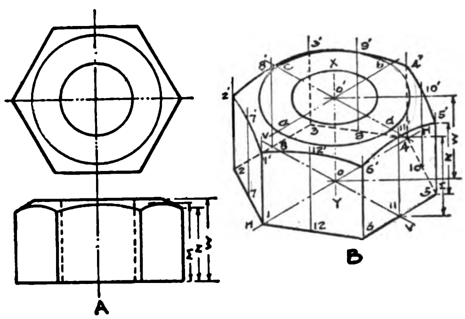


FIG. 44.

35. To Draw an Hexagonal Nut.

In all machine drawing there are always a number of bolt heads and nuts to represent. Fig. 44 is given as illustrating a typical construction, the figure being the representation of an hexagonal nut.

To construct the figure, first draw the center lines *H–H* and *V–V*, and working to them construct the hexagon 1–2–3–4–5–6 as directed in Article 10. Second, at each corner point of the hexagon erect a vertical line, and on each line lay off a length equal to the length of a corner of the nut, locating the points 1′, 2′, 3′, 4′, 5′, and 6′. Third, bisect each side of the hexagon 1–2–3–4–5–6, at each middle point erect a vertical line, and on it lay off a length equal to the greatest width of a side of the nut, locating the points 7′, 8′, 9′, 10′, 11′, and 12′ and giving, with the two points already located, three points in the curve at the top of each side face of the nut. Fourth, draw a curved line (using the irregular curve) through the points thus located, as shown. Fifth, draw the axis *X–Y* through the point *o*, and on it lay off a length *o–o′* equal to the thickness of the nut. Sixth, through the point *o′* draw the center lines *a–b* and *c–d*, and working to them draw the two circles showing in the top face of the nut, in accordance with Article 13, completing the figure.

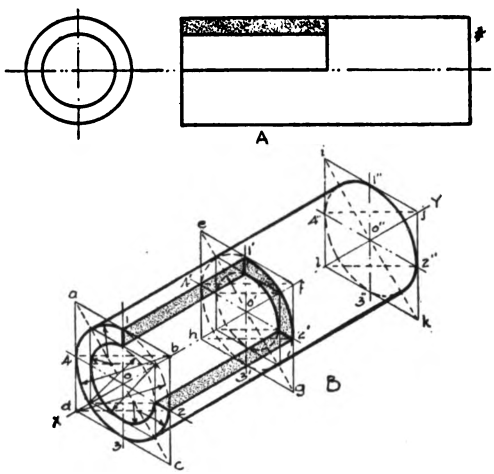


FIG. 45.

36. To Draw a Hollow Cylinder with a Section Removed.

Fig. 45 represents a hollow cylinder with a section removed and is offered to further illustrate the taking of sections in isometric drawing.

To construct drawing *B*, proceed as directed in Article 27 and as suggested by the lines of the figure, and draw the outline of the cylinder; then consider the hole through the cylinder as a second cylinder, and draw its outline in a similar manner. To take out the section, pass a plane *e–f–g–h* through the cylinder, and on it draw the section of the cylinder, as shown; then remove the section between the plane of the front end and the section plane included between the planes 1–1′–*o*′–*o* and *o*–*o*′–2′–2, the construction being evident from the illustration.

37. To Draw Any Solid of Revolution.

Figs. 46 and 47 are illustrations of certain objects with no particular name, but typical of any object of revolution, that

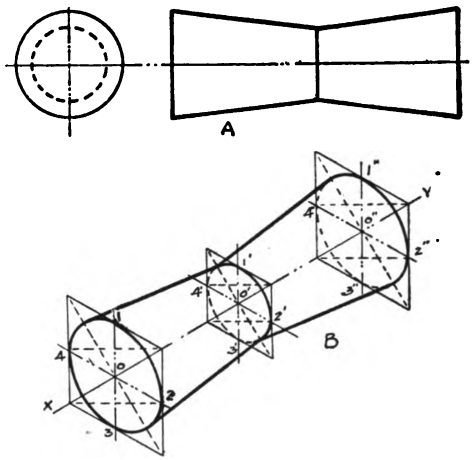


Fig. 46.

is, any object a section at right angles to the axis of which is a circle.

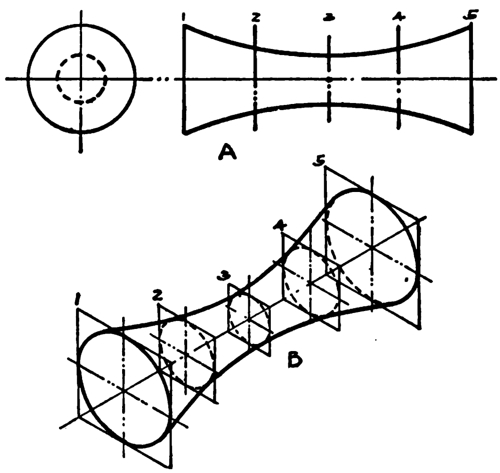


Fig. 47.

To draw such an object, pass a series of transverse sectional planes through it, draw the sections thus taken, then draw the outline of the figure by drawing lines tangent to the sections.

In the further discussion, sections used as above will be called "guide sections."

To construct Fig. 46, first draw the axis *X–Y* and on it locate the points *o*, *o′* and *o″*, according to dimensions as taken from drawing *A* or from the object. Second, at each of the three points draw center lines, and in accordance with Article 13 (taking the diameters of the circles from drawing *A*) draw

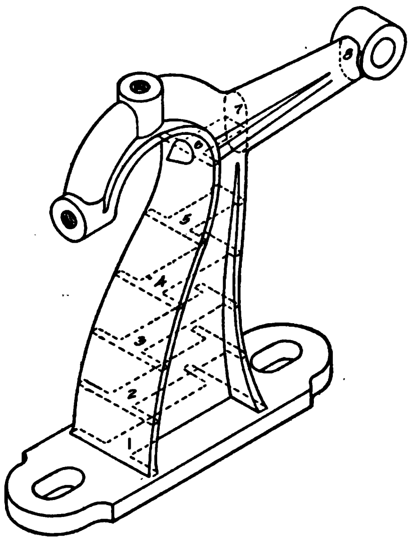


FIG. 48.

the three ellipses, as shown. Third, draw tangent lines to the three ellipses, finishing the figure.

The construction of Fig. 47 is similar to that of Fig. 46, the difference being that three intermediate guide planes are used instead of but one, and the outline of the figure is a curve instead of a straight line, as in Fig. 46.

The use of guide sections is not limited to the construction of representations of solids of revolution, but may be used to advantage when drawing many other types of figures, as, for example, in Fig. 48, where the application is self evident.

38. To Draw a Ring, Circular in Section.

Fig. 49 illustrates a mechanical (*A*) and an isometric (*B*) drawing of a ring which is circular in section.

To execute drawing *B*, first pass a number of radial planes through the ring, as indicated in drawing *A*, cutting the ring in a number of sections. Second, refer the center lines of each section of drawing *A* to the center lines of the figure (as indicated for section number 12), and by plotting establish their position in drawing *B*. Third, on each pair of center lines construct a parallelogram, and within each parallelogram describe

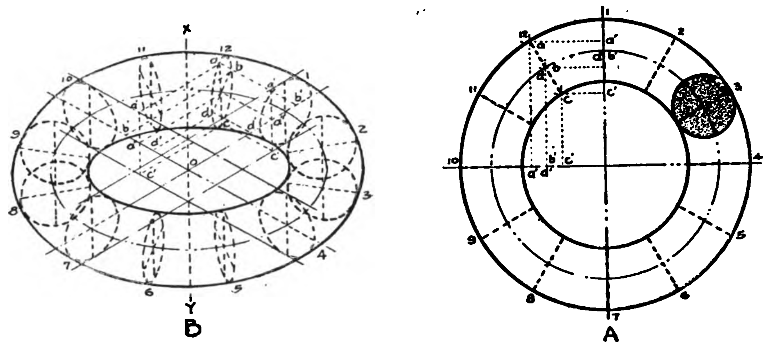


FIG. 49.

an ellipse. Fourth, draw lines tangent to the series of ellipses, all as suggested and shown by the figure.

39. To Draw Screw Threads.

To actually construct a correct representation of a screw thread is a somewhat difficult thing to do and consumes a considerable amount of time. In fact, such a procedure is so laborious and time-consuming that in ordinary mechanical drawing certain conventions are adopted to render the matter practical. This is also true of isometric drawing; for while it is possible to construct a true representation of a thread, it is not worth while, as certain easily executed conventional methods of representation serve very well.

Fig. 50 illustrates one of the conventional representations mentioned, drawing *A* being a mechanical drawing and drawing *B* an isometric drawing.

To construct the isometric drawing, first consider the object as a cylinder and construct the outline of the front and rear bases and connect them with tangent lines as directed in Article 27. Second, on the plane of the front face of the cylinder draw the center lines *H–H* and *V–V* (these will be the same lines as used to obtain the ellipse of the front face), and working to them lay out the construction for the isometric representation of a circle of a diameter equal to the internal diameter of the thread (Article 13). Third, through the points *b* and *e* draw

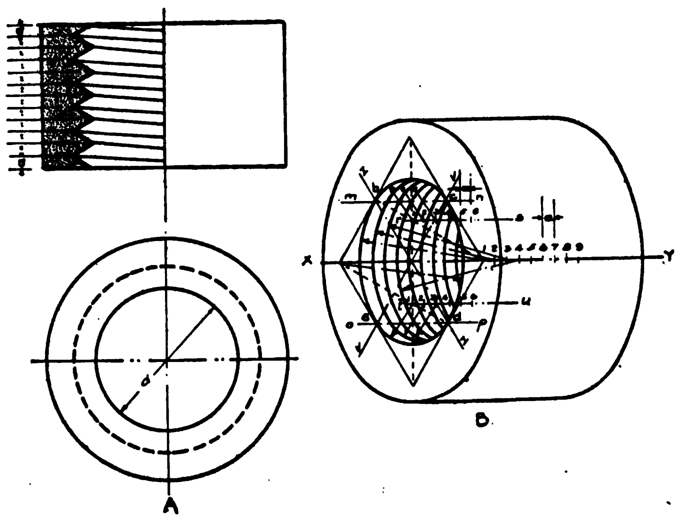


Fig. 50.

the lines *m–n* and *o–p*, respectively. Fourth, beginning at the point numbered 1, lay off a series of divisions on the line *X–Y* equal to the distance between the top and bottom points of the thread; then with the same radius as used to draw the arc *b–e*, and using each of the points 2, 3, 4, etc., as centers, draw a series of arcs parallel to arc *b–e* and terminated by the lines *m–n* and *o–p*. Fourth, through the center points used to draw the arcs *b–c* and *d–e* draw the lines *r–s* and *t–u*, respectively; lay off on each line a series of divisions equal to those laid off on the line *X–Y*, and, with the same radius as used to draw the arcs *b–c* and *d–e*, using each point as a center and picking up each of the arcs first drawn and terminated by the lines *m–n* and *o–p*, continue the curves until they disappear.

Fig. 51 is an illustration of the object illustrated in Fig. 50, showing a section removed and disclosing the points and roots of the thread. The outline of the figure and the arcs representing the thread are drawn as described for the construction of Fig. 50. The new feature introduced by the illustration is the construction of the section of the thread.

The construction of the thread on either side is identical and is illustrated by the lines on the left side. To construct the thread, first draw the two guide lines on *m–n* and *o–p* a distance apart (measured along the center line *b–c*) equal to the depth of the thread. Second, lay off on line *m–n* a series of points 1, 3, 5, 7, etc., a distance apart equal to the distance between points of the thread (equal to the pitch of the thread). Third, bisect the length 1–3, and through the middle point draw the line *r–s* parallel to the center line *b–c* and cutting the line *o–p* in 2. Fourth, join the points 1 and 2; then through each point of division on the line *m–n* draw a line parallel to the line 1–2 and terminating at the line *o–p*. Fifth, join the points

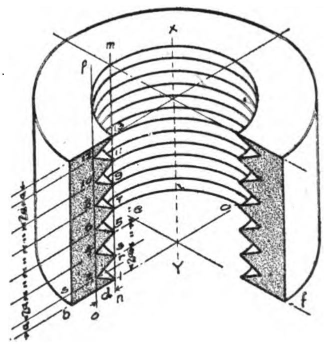


Fig. 51.

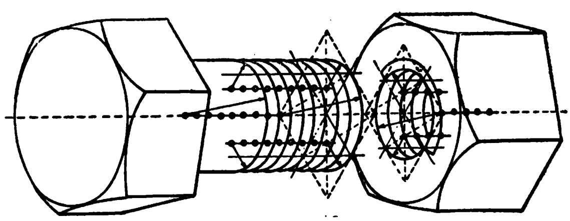


Fig. 52.

2 and 3; then, proceeding as just described, draw the parallel lines 4–5, 6–7, etc., completing the construction.

Figs. 50 and 51 illustrate an inside thread. The construction for an outside thread is similar, and is illustrated by Fig. 52. The parallel curves of Fig. 52 are, however, drawn at a distance apart equal to the pitch of the thread. The matter of the spacing of the center points and the resultant distance between the curves is a matter of opinion with the draughtsman; it may be equal to the pitch, to one-half the pitch, or to something else. As a matter of fact, the whole scheme is but a representation to suggest the thread, and any combination that does this will answer.

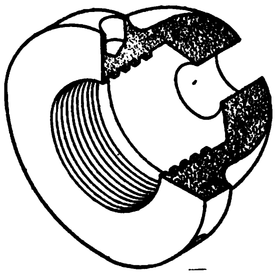
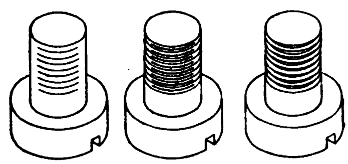


FIG. 53.

Square threads can be illustrated similarly to V-threads, as illustrated by Fig. 53.

Fig. 54 illustrates three other conventions used to represent threads, the construction for each being similar to that already described. The short curve of No. 3 is drawn with a shorter radius than the middle portion of the longer curve, taken optionally by the draughtsman.



No. 1. No. 2. No. 3.

FIG. 54.

40. To Draw a Sphere.

To draw a sphere, execute the isometric representation of a circle of the same diameter as the sphere; then take as a radius a length equal to the semi-major axis of the ellipse so drawn, and draw a circle. The circle will be the isometric representation of the sphere.

The construction described above is illustrated in Fig. 55, drawing *A* being the mechanical drawing and drawing *B* the isometric drawing of the same sphere.

Fig. 56 illustrates a good example of the application of the above construction. The figure illustrates a split-pattern of a small dumb-bell, drawing *A* being a mechanical drawing, drawing *B*–1 an isometric drawing showing the pattern together,

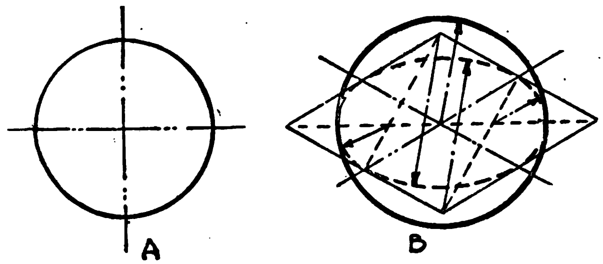


Fig. 55.

and drawing *B*–2 an isometric drawing showing the pattern separated.

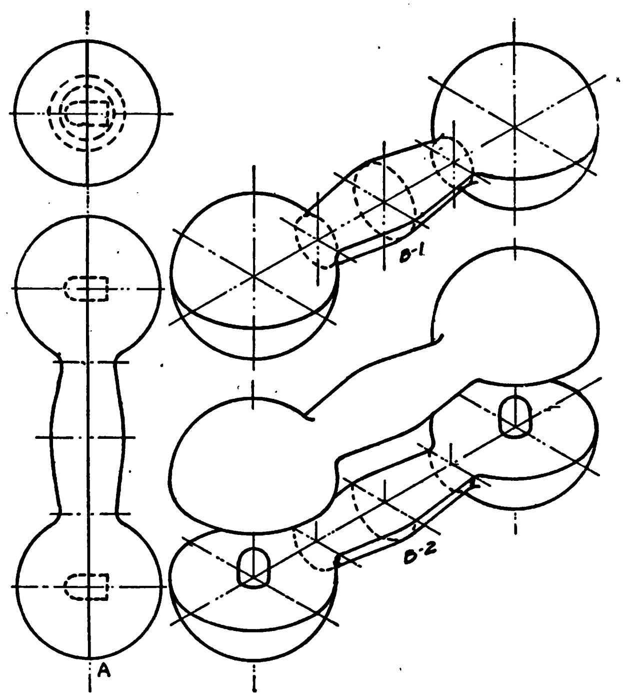


Fig. 56.

Fig. 57 illustrates a good exercise for a beginner. The figures are all isometric drawings, drawing *B* representing a sphere with a horizontal and two vertical (at right angles) great circles

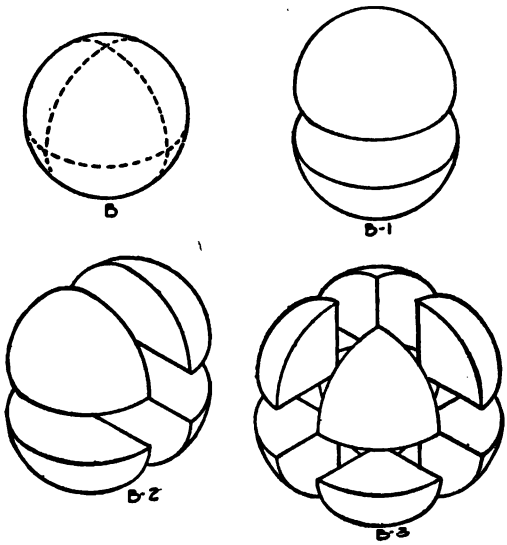


FIG. 57.

on its surface. Drawing *B*–1 illustrates the sphere cut in two along the horizontal great circle and the two halves separated. Drawing *B*–2 illustrates the sphere again cut in two (this time along one of the vertical great circles) and the parts separated, and drawing *B*–3 shows it cut a third time and the parts separated.

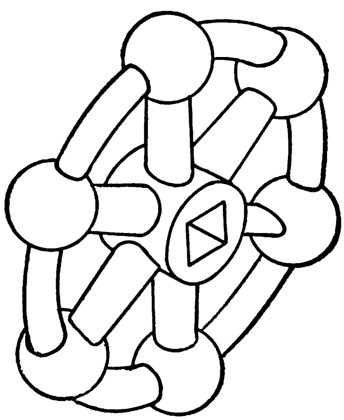


FIG. 58.

Fig. 58, illustrating a hand wheel, is also an excellent type of figure to draw to test one's knowledge of the art and skill in execution.

CHAPTER IV

A COURSE IN ISOMETRIC DRAWING

41. Explanatory.

The following exercises are offered as covering practically all of the different constructions given in Chapters II and III, and as comprising a brief course in isometric drawing. They may be followed exactly, or they may be used as examples only, and similar, original drawings made. It is suggested, however, that the course as outlined be followed out and then supplemented as the student or teacher may elect.

The exercises are planned to go within a border line which is $8'' \times 11''$ in dimensions, and a space $2'' \times 3''$ is reserved for the title of the sheet. The sheets are all alike in this respect, Plate No. 4 showing the lay-out which is to be followed.

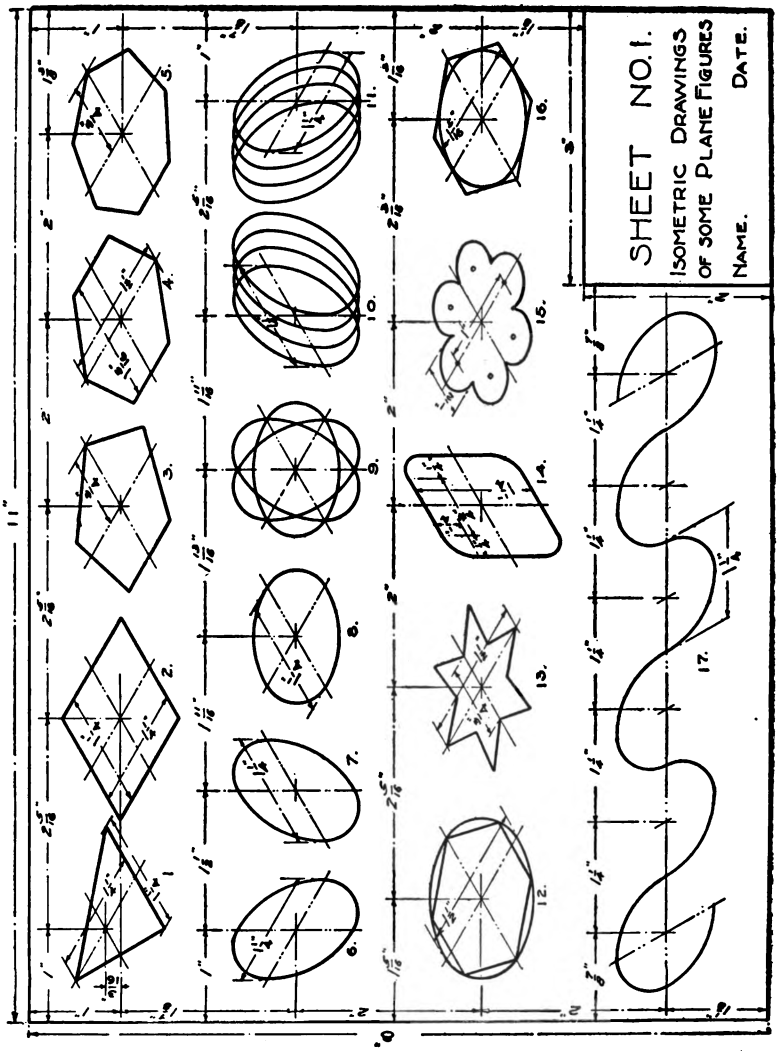

SHEET NO. I.
ISOMETRIC DRAWINGS
OF SOME PLANE FIGURES
NAME.
DATE.

PLATE NO. 4.

42. Sheet No. 1.

Sheet No. 1 is an exercise in the drawing of some plane figures. The sheet is to be laid out, the figures located and drawn full size in accordance with the dimensions given, and the title filled in as shown.

When inking-in, ink the border lines, the outlines of each figure, and its isometric center lines. Omit all dimensioning.

The finished sheet is to have a margin ½″ wide all around outside the 8″×11″ border line, finishing 9″×12″ in dimensions.

The references for the several constructions are to be found in Chapter II. For drawings 1 and 2, see Article 9. For drawings 3 and 5, see Article 12. For drawing 4, see Article 10. For drawings 6, 7, and 8, see Article 13. Drawing 9 is but the grouping of drawings 6, 7, and 8. For drawings 10 and 11, see Article 13 (*f*). For drawings 12 and 16, see Article 13 (*d*) and (*e*). For drawing 14, see Article 18. For drawing 17, see Article 17.

To draw Fig. 13, locate the six points of a hexagon of 1½″ diagonal diameter (Article 10) and the six points of a hexagon of ¾″ diagonal diameter (the latter diagonal to be at right angles to the 1½″ diagonal) and join the points as shown.

To draw Fig. 15, locate the six points of a hexagon of 1″ diagonal diameter (Article 10); through each of the six points thus located draw center lines and working to them (Article 13) construct the isometric representation of a circle of ½″ diameter.

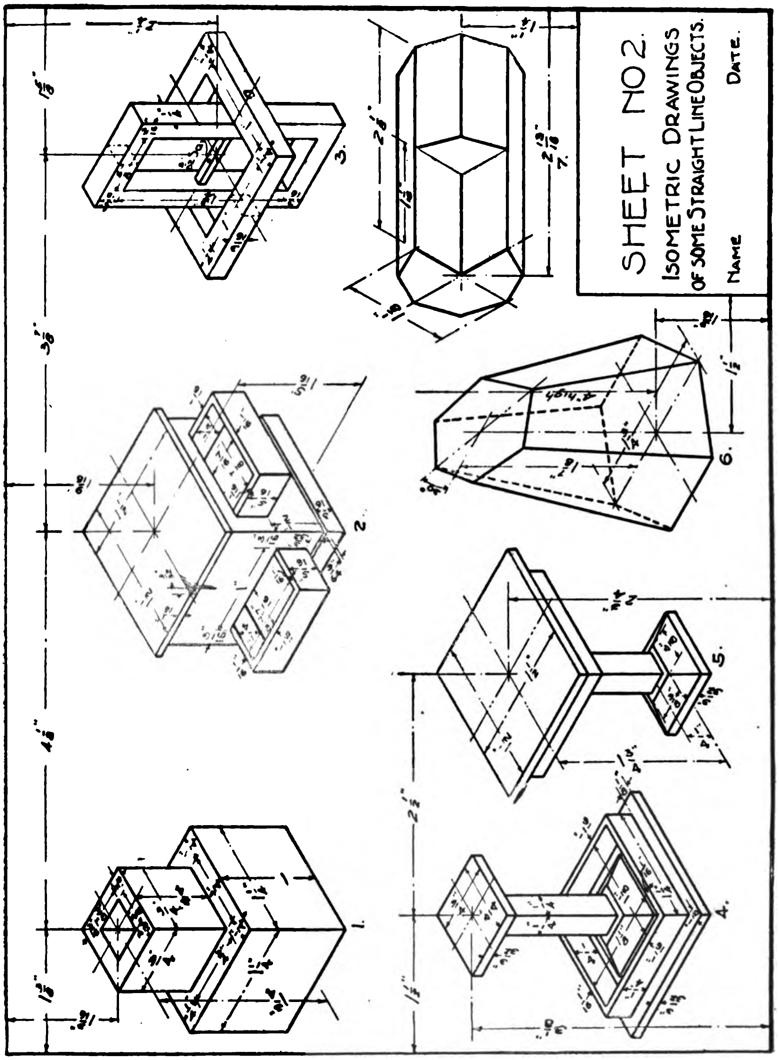

SHEET NO 2.
ISOMETRIC DRAWINGS
OF SOME STRAIGHT LINE OBJECTS.
NAME
DATE.

PLATE No. 5.

43. Sheet No. 2.

Sheet No. 2 is an exercise in the drawing of some straight-line objects.

The dimensions for the sheet, directions for finishing, etc., are the same as for Sheet No. 1.

The references for the several constructions are to be found in Chapter III.

Drawing 1 represents two blocks piled one upon the other; drawing 2 represents a small two-drawer cabinet, showing the drawers pulled part way out; drawing 3 shows two rectangular frames pinned together at right angles one to the other; drawing 5 is a representation of a minature stand; drawing 4, an illustration of the same stand stood upside down; drawing 6 shows a frustum of an hexagonal pyramid; and drawing 7, an octagonal prism with a section removed.

For drawings 1, 2, 3, 4, and 5, see Articles 21 and 22. For drawing Fig. 6, see Article 24. The construction of the upper base of the frustum is left for the student to figure out, the upper base being at 30° with the lower base. For drawing 7, see Articles 24, 25, and 33.

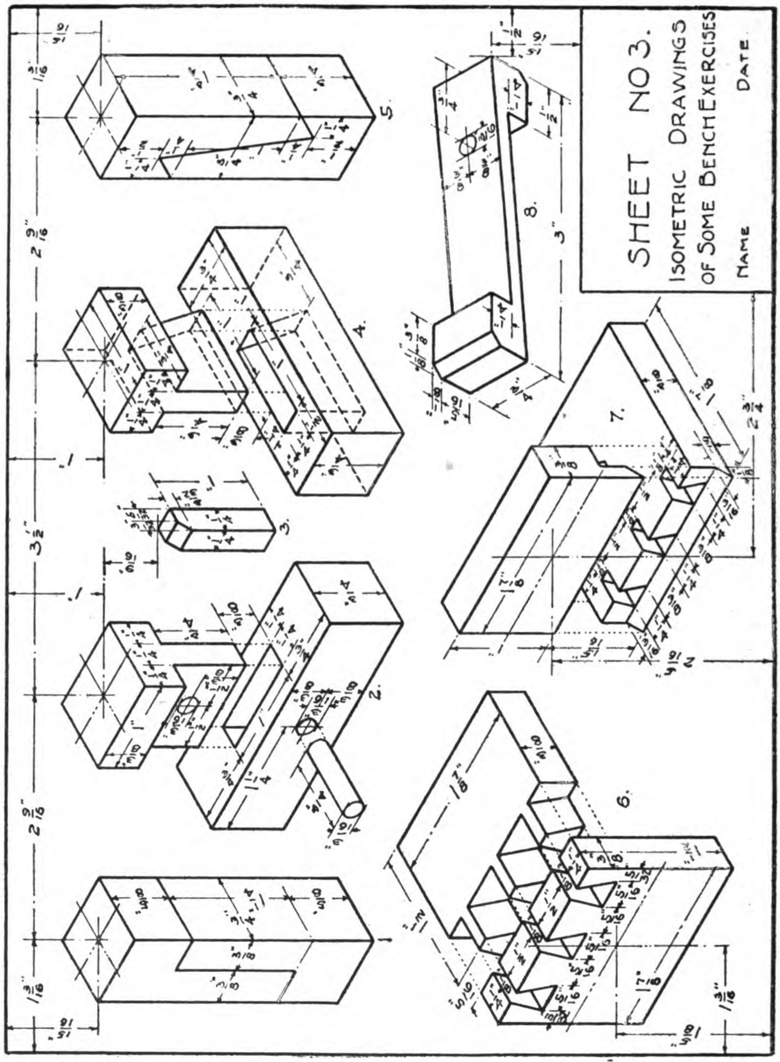

SHEET NO 3.
ISOMETRIC DRAWINGS
OF SOME BENCH EXERCISES
NAME
DATE

Plate No. 6.

44. Sheet No. 3.

Sheet No. 3 is an exercise in the drawing of some examples of bench work.

The conditions for executing the sheet are the same as for Sheet No. 1.

The sheet is very similar to Sheet No. 2, and is offered as giving additional practice in locating and drawing on different planes.

Drawing 1 illustrates a half-splice; drawing 2, a pinned mortise-and-tenon joint, showing the pieces ready to assemble; drawing 4 is a keyed mortise-and-tenon joint, Fig. 3 being the key; drawing 5 shows a splayed splice; drawing 6 illustrates a plain dove-tailed joint; drawing 7, a blind dove-tailed joint; and drawing 8, a bench-hook.

The reference for the entire sheet is to be found in Chapter III, the construction being based on Articles 21, 22, and 27.

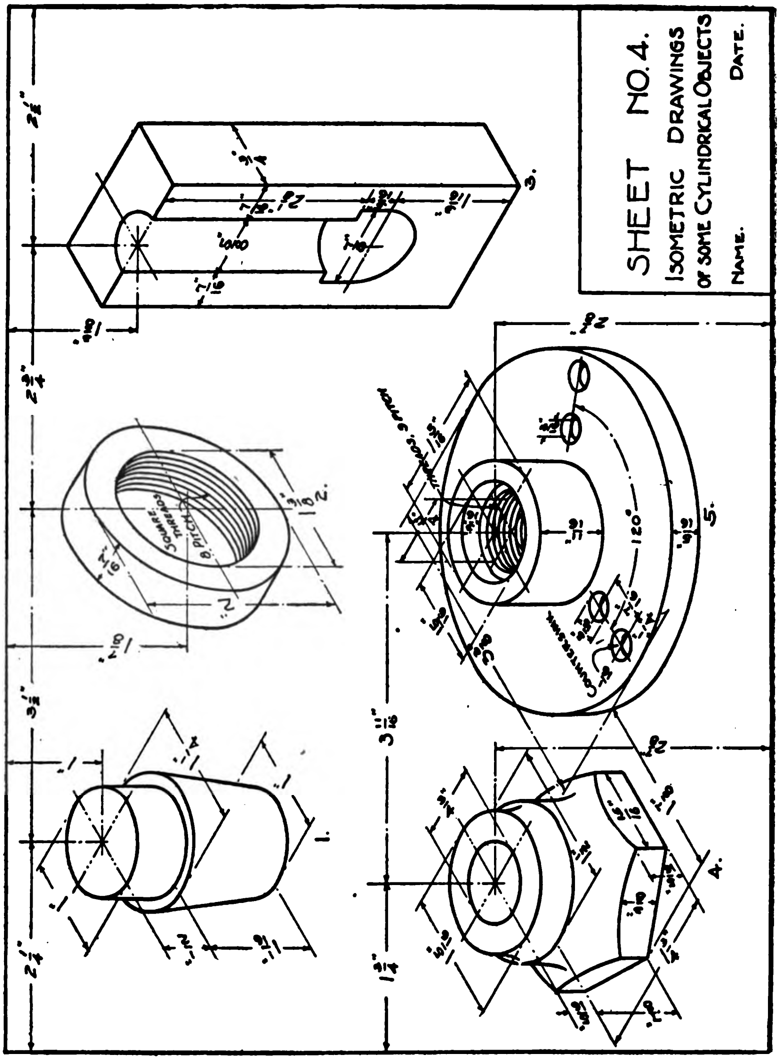

SHEET NO. 4.
ISOMETRIC DRAWINGS
OF SOME CYLINDRICAL OBJECTS
NAME.
DATE.
SQUARE THREADS
8 PITCH
COUNTERSINK
120°

PLATE NO. 7.

45. Sheet No. 4.

Sheet No. 4 is an exercise in the drawing of some cylindrical objects.

The conditions for executing the sheet are the same as for Sheet No. 1.

Drawing 1 is an illustration of a core-print; drawing 2 is a drawing of a circular nut; drawing 3 illustrates a core box; drawing 4 is a special, combination nut-and-spacer; and drawing 5 a face-plate for a wood-turning lathe.

The references for the several constructions are all to be found in Chapter III, and are: For Fig. 1, see Articles 27 and 37; for Fig. 2, see Articles 30 and 39; for Fig. 3, see Articles 21 and 29; for Fig. 4, see Articles 27 and 35; for Fig. 5, see Articles 27, 31 and 39.

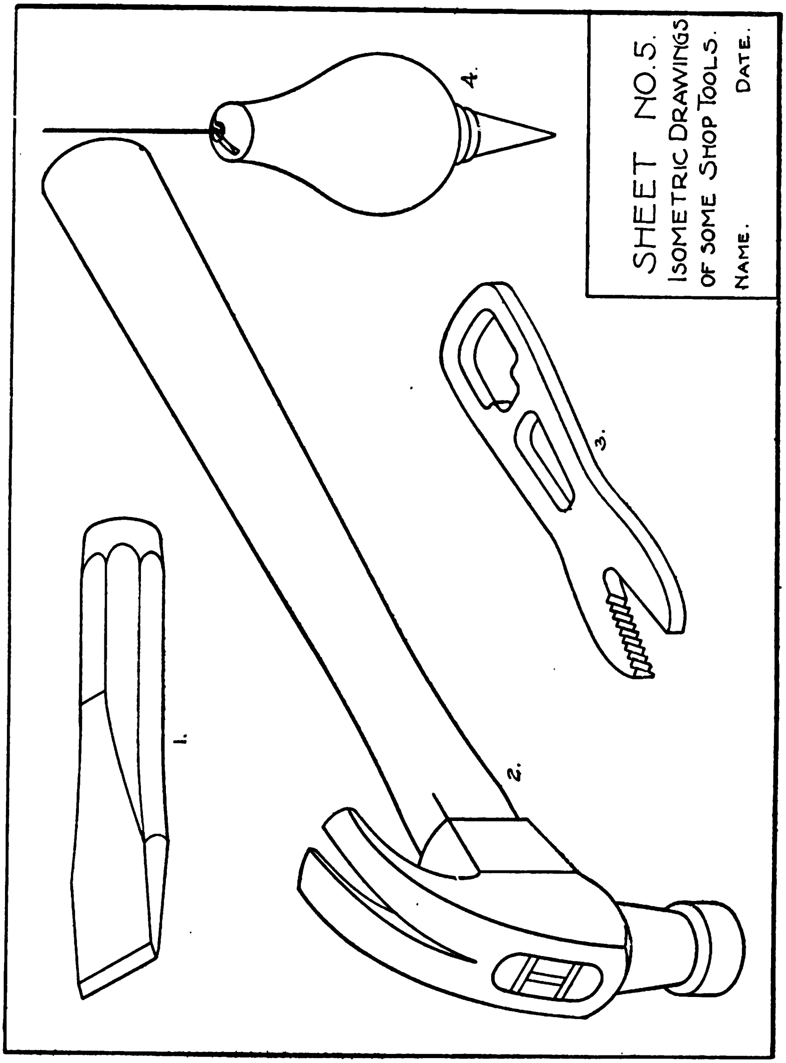

SHEET NO. 5.
ISOMETRIC DRAWINGS
OF SOME SHOP TOOLS.
NAME.
DATE.
1.
2.
3.
4.

PLATE NO. 8.

46. Sheet No. 5.

Sheet No. 5 is an exercise in the drawing of some shop tools.

The sheet is offered as a suggestion only, and is not to be copied, no dimensions being given.

To execute the sheet, it is suggested that the student obtain the same or similar tools as shown by the plate and, working from the tools, draw up an original sheet after the manner illustrated.

The objects illustrated are (1) a cold chisel, (2) a claw hammer, (3) an alligator wrench, and (4) a plumb bob.

All kinds of wrenches, hammers, mallets, screwdrivers, in short, the whole line of hand shop tools make very good examples to illustrate.

47. Suggested Sheets.

The foregoing five sheets are given as typical exercises, and for further exercise work the student or teacher should have very little trouble in elaborating upon the course as given. To this end the following suggestions are offered: A sheet of shop tools other than those illustrated by Plate No. 8; a sheet of pipe fittings, such as tees, ells, union couplings, etc.; a sheet illustrating a globe or other type valve; a sheet illustrating a simple building, or some architectural construction or feature; or, in case the above suggestions are too advanced or the objects named not obtainable, books, blocks, desks, cabinets, and all kinds of furniture and household articles, such as spools, cups, glasses, stove parts, etc., may be used as examples.

48. Remarks.

Dimensioning. Isometric drawings are used more for illustrating than for giving working directions—working or shop drawings. Such being the case, they are not often dimensioned. As before expressed, however, they may be dimensioned, as witness Plates Nos. 4, 5, 6, and 7.

The dimensions may be given in any way which will make them clear to the reader of the drawing, but they look best when applied to the drawing as on the above named plates.

A reference to the plates will show that the dimensions apparently lie in the plane of the part dimensioned, and always in a direction parallel to one of the three isometric directions, that is, either parallel to one of the two center lines or to the axis of the drawing. This practice is recommended.

Enlargement. An isometric drawing drawn full size will appear slightly larger than the object drawn. This feature will, doubtless, have been noted in looking over the figures of Chapter III, as, for example, Figs. 31, 44, 50, 55, and others. There is a reason for this, but it has no connection with the "How" of the art and is purposely not discussed further.

Distortion. Some figures do not appear natural when illustrated by an isometric drawing. This is particularly noticeable in objects of uniform section and of some length. The eye seems to instinctively sense that parallel lines should converge and, since, in isometric drawing they do not, the drawing appears distorted, as, for example, Figs. 50 and 52. This distortion is so marked in some representations that it renders the art unsuited for illustrating that particular object. Distortion is one of the objections to isometric drawing.

Shading. While the examples given in the text are not shaded, or back-lined, it is not to be assumed that isometric drawings cannot be shaded. To shade an isometric drawing, make those lines heavy which represent the intersection of a light and a dark plane, or those lines which cut off the light—the same as in ordinary mechanical drawing.